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Framework Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area:

Volume II – Final Report, Book 1 of 2

Main Report, Appendix A, and Appendix B

Montana Department of
Environmental Quality

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Framework Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area:

Volume II – Final Report

August 31, 2006

Prepared for the Montana Department of Environmental Quality

Prepared by the U.S. Environmental Protection Agency, Montana Operations Office
With Technical Support from Tetra Tech, Inc. and PBS&J

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Acronyms

303(d)	State of Montana's list of threatened and impaired water bodies
ARM	Administrative Rules of Montana
As	Arsenic
BLM	Bureau of Land Management
BMP	Best Management Practice
CFS	Cubic feet per second
Cd	Cadmium
Cu	Copper
CWA	Clean Water Act
DO	Dissolved oxygen
GIS	Geographic information system
GWLF	Generalized Watershed Loading Function model
Hg	Mercury
LSPC	Loading Simulation Program in C
MBER	Montana Board of Environmental Review
MDEQ	Montana Department of Environmental Quality
MFWP	Montana Department of Fish, Wildlife, and Parks
MG/L	Milligrams per liter
MG/M^2	Milligrams per square meter
MM	Millimeters
MRLC	Multi-Resolution Land Characterization
NPDES	National Pollutant Discharge Elimination System
Pb	Lead
SAP	Sampling and Analysis Plan
SSTEMP	Stream Segment Temperature Model Version 2.0
STATSGO	State Soil Geographic Database
TMDL	Total maximum daily load
TN	Total nitrogen
TP	Total phosphorus
TPA	TMDL planning area
TR	Total Recoverable
TSI	Trophic state index
TSS	Total suspended solids
USDI	United States Department of Interior
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
Volume I	Water Quality Restoration Plan and Total Maximum Daily Loads for the Lake Helena Watershed Planning Area (EPA, 2004)
WWTP	Wastewater treatment plant
Zn	Zinc

PREFACE

The Lake Helena watershed restoration planning and TMDL development process will be completed in several steps. Phase I of the restoration planning effort included: 1) completion of a watershed characterization, 2) a review of the applicable surface water quality standards, and 3) an evaluation and description of the basin's water pollution problems based on currently available information. The Phase I effort was intended to provide a foundation for water quality improvement by confirming and documenting existing water quality impairments, evaluating the causes and sources of those impairments, and establishing water quality improvement goals.

The second step of the restoration planning effort, Phase II, included a more detailed assessment of pollution sources, refinement of the water quality improvement goals (or targets), and development of the actual TMDLs, pollutant load allocations, and a conceptual restoration strategy and effectiveness monitoring plan. The Phase II effort, which is reflected in this document, provides a general conceptual plan to attain and maintain the necessary water quality improvements. It does not, however, provide in-depth details about how the plan will be implemented on a site-specific basis.

Future activities that will be pursued under Phase III of the project include: 1) supplemental studies to address remaining uncertainties identified in Phase II, 2) selection and implementation of actual water quality restoration measures, 3) ongoing planning and coordination among watershed stakeholders, and 4) continued monitoring to evaluate success.

It is important to note that TMDLs are not self-implementing, in part because neither the federal Clean Water Act nor the Montana Water Quality Act provides any specific authority for implementing TMDLs. TMDLs are only implemented through other programs and statutory mechanisms. The actual implementation measures include both regulatory and voluntary components that will need to be lead by local stakeholders. Implementation of the Lake Helena water quality restoration plan will be an ongoing process involving adaptive management and continuous fine-tuning. Given the complexity and scale of water quality issues in the Lake Helena watershed, it is not possible to address every detail of plan implementation in this Phase II document.

The conclusions and recommendations presented in this report are based on the most current available information. Remaining uncertainties have been disclosed and, in most cases, a general plan has been laid out for filling the information gaps. However, we acknowledge that some questions may never be completely answered and there will be a need to accept some degree of uncertainty. As new information becomes available in the future and as conditions change, a strategy to evaluate and apply the new information must be in place. This in essence is what adaptive management is all about.

Many of the public comments and questions received on the Phase II report will be addressed during Phase III of the project. These include defining: 1) the types, locations and feasibility of restoration measures that will be applied on the ground, 2) the roles of the agencies and other stakeholders in implementing pollution controls, 3) how implementation activities will be prioritized on a geographic and pollution specific basis, 4) how point source and non-point source pollution controls will be balanced on a watershed wide basis and whether trading between categories can be accommodated, 5) how best to reduce uncertainty and risk, and 6) funding mechanisms for plan implementation.

Phase II of the Lake Helena water quality restoration plan addresses the formal requirements of the TMDL process and establishes a foundation for moving forward. However, the ultimate success of the plan in improving and maintaining water quality into the future lies with the basin's stakeholders.

1.0 INTRODUCTION

In simple terms, a total maximum daily load (TMDL) is a plan to attain and maintain water quality standards in waters that are not currently meeting them. The waters not currently meeting water quality standards in the Lake Helena watershed have been identified and described in Volume I of the *Water Quality Restoration Plan and Total Maximum Daily Loads for the Lake Helena Watershed Planning Area* (EPA, 2004) (referred to in this document as "Volume I").

This document represents Volume II of the restoration plan. It consists of a framework plan to attain and maintain water quality standards in all of those waters considered impaired in Volume I. This document has been written and structured to be readable by both a non-technical audience as well as by those who may be interested in the technical details and regulatory context. The main body of the Volume II report includes a summary of the approach and methods, a description of the water quality problems, a presentation of water quality goals, a summary of the sources of the water quality problems, and a conceptual plan for addressing the water quality problems. The main body of Volume II is intended to provide an overview of the issues and the proposed solutions at the watershed scale.

The required TMDL elements for each of the water body/pollutant combinations described in Volume I are presented in a separate appendix to facilitate easy review by regulators, affected watershed stakeholders, and others interested in site specific water quality restoration recommendations (Appendix A). Appendix A is presented at the individual water body and sub-watershed scale.

The technical details, including modeling and assessment methods, technical analyses and results are also provided in appendices to this report. These are referenced throughout the main body of this document.

Document Contents

The main body of this document presents an overview of water quality issues and proposed solutions at the watershed scale.

The TMDLs, and details at the sub-watershed scale, are presented in Appendix A.

Supporting technical analyses are presented in Appendix B through K.

2.0 APPROACH/METHODS

Approach

The Volume II report provides a framework plan for restoring water quality. A phased implementation approach coupled with an adaptive management strategy is proposed. Actual implementation will occur in Phase III.

The water quality issues in the Lake Helena watershed are numerous, technically complex, and involve a large number of varied stakeholders ranging from federal and state resource agencies to county and local governments, industry, the agricultural community, and watershed residents. While it is believed that the efforts summarized in Volumes I and II have advanced our understanding of water quality problems in the Lake Helena watershed considerably, given the available time and resources, it is not possible at this time to prescribe a definitive plan of action to specifically address all of the issues in a detailed fashion. Instead, the intent of this plan is to provide a framework within which the most significant water quality problems can be identified and prioritized so that watershed stakeholders have the information they need to begin improving water quality conditions. It is also envisioned that the information presented in this plan, and some of the tools that have been prepared in support of developing this plan (e.g., water quality models), will provide a framework with which to make informed future decisions regarding water quality.

The overall approach for restoring water quality in the lakes and streams in the Lake Helena watershed is three-phased beginning with information gathering in Phase I, plan development in Phase II, and implementation in Phase III. A summary of the phased approach is presented in Table 2-1.

Phase I goals included:

1. Developing an understanding of the physical, biological, and socioeconomic characteristics of the Lake Helena watershed that are influencing water quality;
2. Verifying and understanding the water quality impairment status of all Lake Helena watershed water bodies appearing on Montana's 303(d) lists; and
3. Determining which water bodies are in need of Total Maximum Daily Loads.

The Lake Helena Volume I report was completed in December 2004 and summarized the results of the Phase I effort. Volume I was made available to the public in February 2005 and public comment has helped to shape Phase II. A summary of the public comments received on Volume I and agency responses are presented in Appendix B of this report. Summaries of the conclusions from the Volume I report have been reiterated in this document. However, for more detailed information on the status of each water body discussed in this report and requiring a TMDL, the reader is referred to the Volume I document.

The purpose of Phase II was: 1) to identify and characterize the sources of the water quality problems described in Volume I, 2) to establish water quality goals or endpoints that can be used to define attainment of water quality standards in the future, and 3) to frame solutions for addressing each of the significant water quality problems and their sources. The required TMDL elements, including water quality targets, total maximum daily loads, pollutant allocations, and margins of safety, are presented in Phase II. Collectively, the Phase II planning effort and the Volume II report comprises the framework plan for attaining and maintaining water quality standards.

During Phase III of the project, the necessary follow-up and/or supplemental studies will be conducted to address uncertainties identified in Phase II and to implement the necessary actions to attain and maintain water quality standards. As was mentioned in the preface to this report, it is important to note that TMDLs are not self-implementing. Neither Section 303(d) of the Clean Water Act nor the Montana Water Quality Act creates any implementing authorities. TMDLs are only implemented through other Programs and statutory mechanisms. Implementation tools vary and may include:

- National Pollutant Discharge Elimination System (NPDES) permits
- Other federal, state and local laws and requirements (enforceable as well as voluntary)
- Individual voluntary actions

A conceptual implementation strategy is presented in Section 4.0 of this document. However, describing actual site specific implementation measures is beyond the scope of Volume II and will rely upon a combination of regulatory and voluntary means that will need to be lead by watershed stakeholders.

An adaptive management approach will be a key component of plan implementation. Given the complexity and scale of water quality issues in the Lake Helena watershed, it will not be possible to answer every question and address each detail in this document. Conclusions reached and decisions made/documented in Volume II are based on the best information and data currently available. As new information becomes available in the future and/or conditions change, a strategy to evaluate the new information, react to it, and adjust components of the plan must be in place. Case-specific adaptive management strategies are presented throughout the document as they are needed. Adaptive management is also discussed in the conceptual implementation strategy (Section 4).

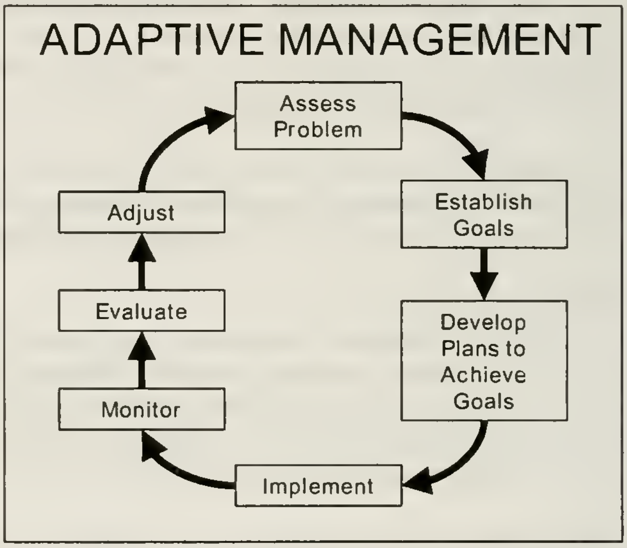


Table 2-1. Phased water quality restoration planning approach.

2003 – 2004	2005	2006 →
Phase I – Information Gathering	**Phase II - Planning**	**Phase III – Proposed Implementation**
• Developing an understanding of the water quality problems. • Determined which water bodies needed TMDLs. • Solicited public comments. • Completed Volume I report.	• Revised some of the conclusions reached in Volume I based on public comments. • Identified the pollutant sources and relative importance of each. • Established water quality goals. • Developed a pollutant load reduction plan to attain the water quality goals. • Completed Volume II report.	• Implement a coordinated effort at the watershed scale to reduce pollutant loading from both point and non-point sources. • Conduct follow-up and/or supplemental studies to address uncertainties identified in previous phases. • Revise, adjust, and manage adaptively as appropriate based on new information.

3.0 WATER QUALITY RESTORATION IN THE LAKE HELENA WATERSHED

To a large extent, current water quality in the Lake Helena watershed is a result of man's activities within the watershed over the last 100 to 150 years. In the mid-1800s, mining activity increased following the discovery of gold and other minerals in the mountains around the Helena Valley. At the same time, the earliest miners and homesteaders began diverting water from Prickly Pear, Tenmile, and Silver creeks to irrigate land for crops. Together, the watershed's hydrology and water quality experienced a period of rapid change due to these land development activities. Today, several hundred abandoned mines are present in the watershed and these continue to influence basin hydrology and water quality (MBMG, 2004).

In 1907, the hydrology of the Helena Valley was further altered with the completion of Hauser Dam and Reservoir on the Missouri River north of Helena. As the reservoir filled, the low lying wetlands of Prickly Pear and Silver creeks flooded to form Lake Helena. In 1945, an earthen causeway and control structure was built to separate Hauser Reservoir and Lake Helena, allowing the two to be regulated independently.

Between 1940 and 1970, extensive logging occurred in the Lake Helena watershed, primarily in the western portions of the watershed along the Continental Divide where the most valuable timber was located. During this period, equally extensive road networks were built to facilitate harvest and transport of the timber. Many of the stream impacts observed today (particularly those associated with stream channel morphology and excess sediment) are remnants from these earlier activities (personal communication, Carl Davis, Helena National Forest Archaeologist, 2005).

Population growth and the associated infrastructure have also permanently altered the landscape and have and will continue to play a role in defining water quality in the Lake Helena watershed. Since the 1950s, population growth has averaged approximately 18 percent per decade. In summary, the water quality conditions and problems present today in the Lake Helena watershed are a function of past and present land uses.

The Volume I report included an assessment and description of the known pollution problems based on the currently available data. It separately addressed each of the water bodies that have appeared on past Montana 303(d) lists. Based on these assessments, the primary pollutants of concern in the lake Helena watershed include sediment, nutrients, metals, and water temperature. The remainder of Section 3.0 of this report presents a watershed scale overview of these water quality problems, including a summary of the sources of each pollutant, water quality improvement goals, and proposed solutions for ultimately attaining and maintaining the relevant water quality standards. Detailed discussions of prescriptions for each individual water body and the associated TMDL elements are presented in Appendix A of this report.

3.1 SEDIMENT

The Problem:	Fish and aquatic life designated uses are not meeting their full potential in many streams due to excessive levels of sediment covering fish spawning and macroinvertebrate (aquatic insect) habitat, filling pools, and altering stream channel morphology.
Water Bodies of Concern:	Clancy Creek, Corbin Creek, Jennies Fork, Lump Gulch Creek, Middle Fork Warm Springs Creek, North Fork Warm Springs Creek, Warm Springs Creek, Prickly Pear Creek, Sevenmile Creek, Skelly Gulch, Spring Creek, and Tenmile Creek.
The Source:	Human-caused erosion primarily from unpaved roads, agriculture, timber harvest, streambank erosion, abandoned mines, non-system roads, and urban areas.
In-Stream Sediment Goals:	Attain and maintain the applicable sediment water quality standards.
The Solution:	Reduce sediment loading from each of the significant human-caused sources.

Technical reports prepared in support of the sediment overview presented in this section of Volume II include:

- ***Appendix A*** *– Total Maximum Daily Loads (TMDL) Summary*
- ***Appendix B*** *– DEQ and EPA Response to Public Comments Received on the February 28, 2005 Volume I Draft Document*
- ***Appendix C*** *– GWLF/BATHTUB Modeling Results*
- ***Appendix D*** *– Supplemental Sediment Source Assessment Results*
- ***Appendix H*** *– Supplemental Monitoring and Assessment Strategy*
- ***Appendix J*** *– Wasteload Allocations for Regulated Stormwater Discharges*

3.1.1 The Sediment Problem and Water Bodies of Concern

The surveyed streams in the Lake Helena watershed that are not currently meeting Montana's narrative sediment standards are listed below and shown on Figure 3-1. The Volume I report provides details regarding the degree of impairment and how the impairments are manifested in each of these water bodies. In general, sediment is causing a loss of benthic (i.e. fish food) productivity and fish habitat. Additionally, in some streams human-caused sediment loading is resulting in unnaturally high levels of turbidity.

- Clancy Creek (MT41I006_120)
- Corbin Creek (MT41I006_090)
- Jennies Fork (MT41I006_210)
- Lump Gulch (MT41I006_130)
- Middle Fork Warm Springs Creek (MT41I006_100)
- North Fork Warm Springs Creek (MT41I006_180)
- Warm Springs Creek (MT41I006_110)
- Prickly Pear Creek (MT41I006_060)
- Prickly Pear Creek (MT41I006_050)
- Prickly Pear Creek (MT41I006_040)
- Prickly Pear Creek (MT41I006_030)
- Prickly Pear Creek (MT41I006_020)
- Sevenmile Creek (MT41I006_160)
- Skelly Gulch (MT41I006_220)
- Spring Creek (MT41I006_080)
- Tenmile Creek (MT41I006_142)
- Tenmile Creek (MT41I006_143)

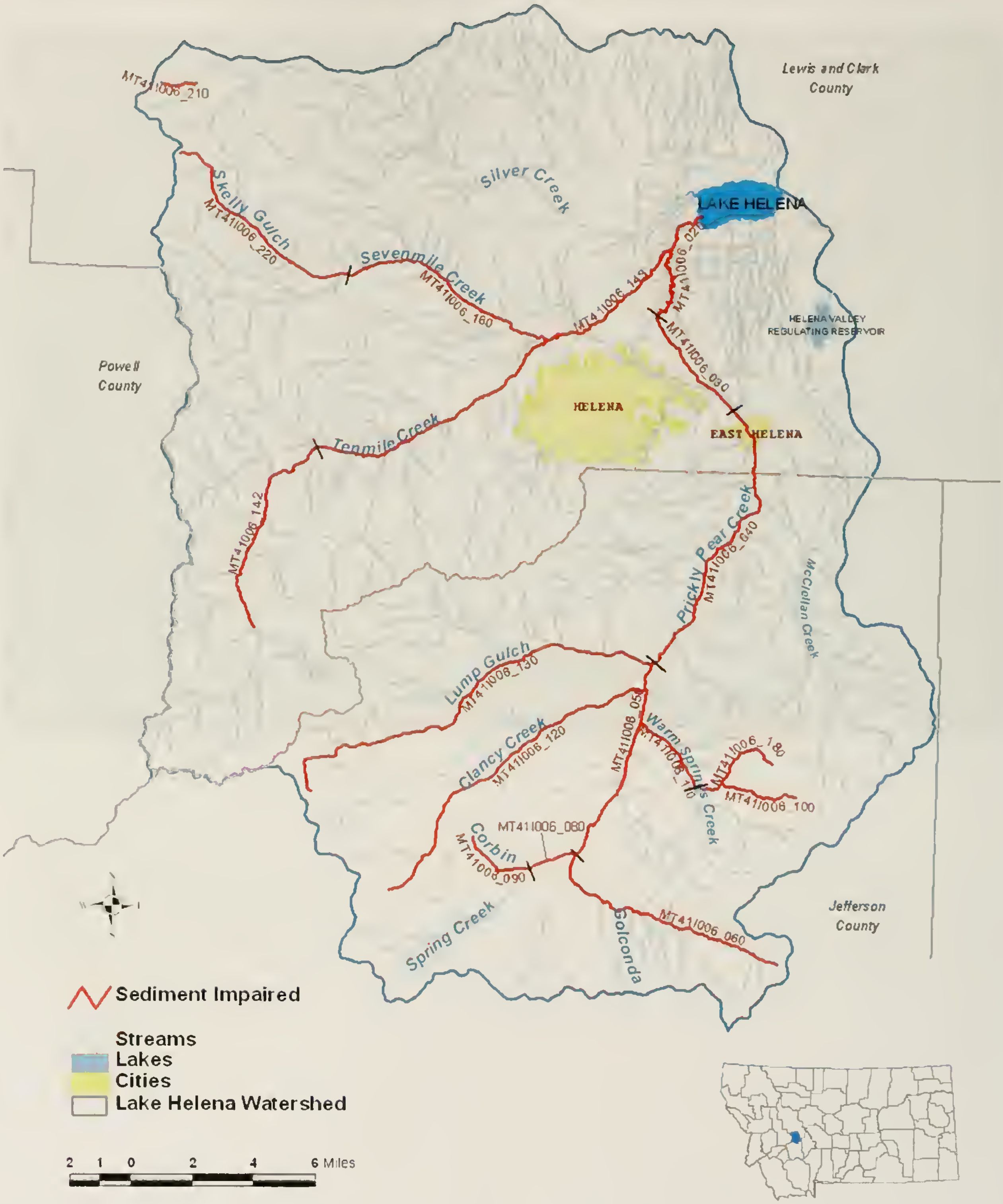


Figure 3-1. Sediment impaired water bodies in the Lake Helena watershed.

3.1.2 Sources of Sediment in the Lake Helena Watershed

In general, excessive sediment loading from a variety of human-caused sources is the cause of the sediment impairment. Potential sources of sediment considered in this analysis included paved and unpaved roads, agriculture, timber harvest, streambank erosion, stormwater, mining, and a variety of natural sources (e.g., undisturbed forest, undisturbed grassland, etc.). The estimated sediment loads from each of these sources for each of the impaired streams are presented in Appendix A. Source loads were estimated using the Generalized Watershed Loading Function model (GWLF, see Appendix C) in combination with information gathered from remote sensing techniques, field surveys, streambank stability studies, and site-specific road analyses (see Appendix D).

When considering all of the above listed stream segments together, unpaved roads, agriculture, timber harvest, streambank erosion, abandoned mines, non-system roads, and urban areas contribute an estimated 15, 10, 10, 7, 3, 1, and 1 percent of the total sediment load, respectively (Figure 3-2). On average, sediment loading is estimated to be approximately 47 percent above the naturally occurring level.

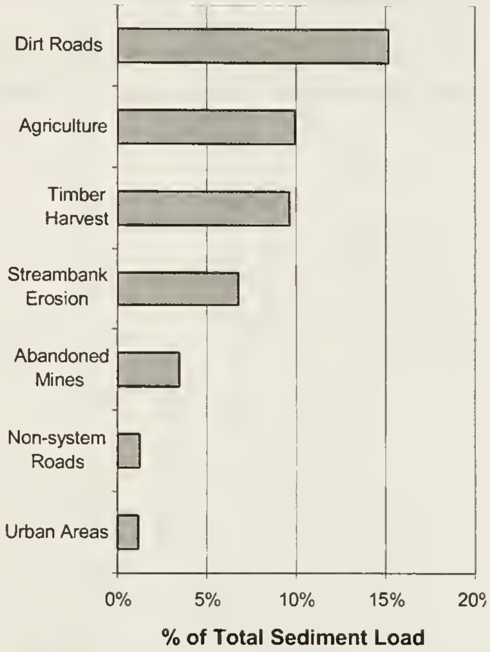


Figure 3-2. Average sediment loads in the Lake Helena watershed.

The relative importance of individual source categories (e.g., unpaved roads, agriculture, etc.) varies dramatically from stream to stream (see Appendix A). For example, agricultural sediment loading tends to increase in importance in the downstream reaches of the Lake Helena watershed. In contrast, the relative importance of sediment loading from unpaved roads, timber harvest and abandoned mining tends to increase towards the headwaters regions of the watershed. Human-caused streambank erosion is an important6 source of sediment loading throughout the watershed.

3.1.3 In-stream Sediment Goals

The ultimate goal of this water quality restoration plan and associated TMDLs is to attain and maintain water quality standards. Montana's water quality standards for sediment are narrative in form and therefore must be interpreted to derive measurable water quality goals. A suite of measurable sediment indicators was developed and described in the Volume 1 report to facilitate interpretation of the narrative sediment standards. This suite of indicators was selected based on the best data and information available when Volume I was completed. Since that time, EPA and Montana DEQ have begun to develop a new suite of biological indicators that, when fully developed, may replace the biological indicators presented in Volume I. Also, since Volume 1 was completed MDEQ has begun to develop a new methodology for interpreting/translating the narrative sediment criteria. When this methodology is completed, the sediment goals presented in Volume I may also need to be revised.

Since the success of this plan and associated TMDLs will be formally evaluated five years after it is approved (i.e., 2011 assuming TMDL approval in 2006), flexibility must be provided herein with the proposed suite of indicators that have been selected to interpret the narrative sediment standards. The indicators presented in Table 3-1 are proposed as endpoint water quality goals (or targets) for sediment, in recognition of the fact that they may be subject to future revisions as new information becomes available or MDEQ implements a new approach for interpreting the narrative sediment standards.

The suite of indicators used to evaluate compliance with Montana's sediment standards in the future should be selected based on the best data, information, and methods available at that time.

Table 3-1. Proposed sediment water quality endpoints.

Water Quality Indicators	Rationale for Selection of this Indicator	Proposed Criteria
Percentage of subsurface fines < 6.4 mm size class, expressed as a reach average, in McNeil core samples collected in trout spawning gravel beds.	Fine grained substrate materials less than 6 mm are commonly used to describe potential success of fry emergence, and this size class includes the range typically generated by land management activities. There is an inverse relationship between the percentage of material < 6 mm and the emergence success of westslope cutthroat trout and bull trout (Weaver and Fraley, 1991). This indicator provides information regarding sediment supply (i.e., is there too much sediment?) and an indirect linkage between sediment supply in a stream and potential impacts to the coldwater fishery.	The reach average value must be less than or equal to the average value for all Helena National Forest reference stream core samples.
Percentage of surface fines < 2.0 mm size class	Studies have shown that increased fine grained substrate materials less than 2 mm can adversely affect embryo development success by limiting the amount of oxygen needed for development (Meehan, 1991). As with the previous indicator, this indicator provides information regarding sediment supply (i.e., is there too much sediment?) and an indirect linkage between sediment supply in a stream and potential impacts to the coldwater fishery. This indicator also provides an indirect linkage to potential impacts to macroinvertebrates.	≤ 20%
Channel width/depth ratio	The bankfull width to depth ratio is indicative of the 'quasi-equilibrium' relationship between stream discharge and load transport (Ritter et al. 1995). Increasing width to depth ratio is correlated to stream aggradation and bank erosion (Knighton, 1995 and Rowe et al., 2003).	Comparable to reference values.
Bank erosion hazard index (BEHI) score	The bank erosion hazard index is a composite metric of streambank characteristics (bank height, bankfull height, rooting depth, bank angle, surface protection, and bank materials/composition) (Rosgen, 1996). Measurements for each metric when combined produce an overall score of bank erosion potential. Low values indicate a low potential for bank erosion.	Comparable to reference values.
Median surface particle size (D_{50})	A clear trend of decreasing particle sizes in riffles is correlated with increasing hillslope disturbance. Moreover, there is a statistically significant difference in average and minimum D_{50} values when comparing reaches in undisturbed and less disturbed watersheds with reaches in moderately and highly disturbed watersheds (Knopp, 1993).	Comparable to reference values.
Proper Functioning Condition (PFC) riparian assessment	The PFC method is a qualitative method for "assessing the physical functioning of riparian-wetland areas" (Prichard, 1998). The hydrologic, riparian, and erosion/deposition processes of a stream reach are evaluated. Reaches that are in proper functioning condition typically have minimal riparian disturbance, stable streambanks, and the ability to withstand high discharge events.	"Proper Functioning Condition" or "Functional – at Risk" with an improving trend.
Macroinvertebrate IBI (to be determined)	A measure of macroinvertebrates will provide a direct measure of aquatic life health. However, it should be noted that this indicator will not directly provide information regarding potential violations of Montana's narrative sediment standards.	To be determined.

3.1.4 The Solution

The hypothesis put forth in this plan is that the water quality standards (as measured by the indicators and approach presented in Section 3.1.3) will be met if all reasonable land, soil, and water conservation practices are fully applied to each of the significant sediment sources (e.g., unpaved roads, agriculture, timber harvest, streambank erosion, abandoned mines, non-system roads, and urban areas). Specific sediment load reduction goals have been proposed for each of these sediment sources (see Appendix A). It is assumed that the load reduction goals equate to the application of all reasonable land, soil, and water conservation practices.

The proposed load reduction goals for each sediment source category and their rationale are presented in Table 3-2. Uncertainties are also acknowledged and discussed. Monitoring and adaptive management strategies to address these uncertainties are presented in Section 4.0. Sediment TMDLs are presented in Appendix A.

All Reasonable Land, Soil, and Water Conservation Practices

On average, sediment loads to the impaired streams in the Lake Helena watershed must be reduced by approximately 47 percent to achieve "natural" sediment loading levels. However, Montana's water quality standards recognize that it may not be possible to achieve pre-human settlement, pristine water quality conditions. Montana's water quality standards define "naturally occurring" conditions as those where all designated beneficial uses are supported and all "reasonable, land, soil, and water conservation practices" are employed. In other words, there is some allowance for human activity so long as all designated beneficial uses are supported.

Table 3-2. Sediment load reduction approach by source category.

Source Category[1]	Pollutant Load Reduction Approach, Rationale, and Assumptions	Uncertainty
Current Timber Harvest	It is assumed that sediment loading from currently harvested areas will return to levels similar to undisturbed forest through natural recovery and application of BMPs. The GWLF model was used to estimate the load reductions associated with re-growth of vegetation in the harvested areas.	Because private harvest data were not available, the assumption was made that harvesting occurs at a continuous rate allowing for a 90-year harvest cycle (1/90 of private land is harvested each year). However, it is more likely that large cuts occur sporadically. Therefore, load reductions in any individual sub-watershed could be over or underestimated.
Unpaved Roads	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated sediment load and load reduction may be an overestimation.
Non-system roads	Ideally all non-system roads should be closed and reclaimed. It is assumed that sediment loads from this source category will be eliminated.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimation.
Urban Areas	The effectiveness of urban stormwater BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from vegetated buffer strips to engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed (Schueler, 1997; Barnes and Gerde, 1993)	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimation.
Anthropogenic Streambank Erosion	The goal for this source category is to reduce all human-caused streambank erosion to levels expected in undisturbed or least impaired reference streams. Reference levels have been estimated based on Bank Erosion Hazard Index (BEHI) scores from reference streams in the Beaverhead-Deerlodge National Forest as follows: A channels = 21.06, B channels = 20.49, C channels = 20.32, and E channels = 18.77 (Bengeyfield, 1999). (See Appendix D)	It may not be practical or possible to restore all areas of human-caused streambank erosion to reference levels. Therefore, this load reduction may be an overestimation.
Abandoned Mines	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 79% (See Appendix D).	The range of observed sediment load reductions from past reclamation at five mines in the study area ranged from 0 to 100%. Therefore, load reductions could be over or underestimated.
Agriculture	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed resulting in a 60% sediment load reduction and alternative crop management practices will minimize the area of bare soil.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimation.
Other Sources	A variety of other potential sediment sources have been considered in this analysis, but were not determined to be significant at the watershed scale. Where other sources, not discussed herein, are determined to be important at the sub-watershed scale, they are discussed in Appendix A.	Uncertainties associated with proposed load reduction approaches for other sources that may be important at the sub-watershed scale are addressed individually in Appendix A.
Natural Background	No load reductions are proposed from source categories considered natural (e.g., undisturbed forest lands, undisturbed grasslands, etc.).	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human activities that could be controlled.

[1] Sediment sources vary by sub-watershed, and not all sub-watersheds have all of the listed sediment sources.

3.2 NUTRIENTS

The Problem:	Excessive nutrient loading is resulting in nuisance levels of algae and low dissolved oxygen concentrations in some streams, thereby impairing the recreation and fish and aquatic life designated beneficial uses. Available data also suggest that nutrients may be decreasing water clarity and increasing the incidence of algal blooms in Lake Helena and Hauser Reservoir. If population growth in the watershed continues at current rates and nutrient loading is not curbed, water quality is predicted to deteriorate further.
Water Bodies of Concern:	Prickly Pear Creek, Sevenmile Creek, Spring Creek, Tenmile Creek, Lake Helena.
The Source:	Nutrient loading from point and non-point sources.
Nutrient Goals:	The ultimate goal is to attain full beneficial use support relative to nutrient caused impairments. While sufficient information is available to determine that beneficial uses are impaired by nutrients, data are presently inadequate to support the adoption of final nutrient threshold values for all Lake Helena watershed water bodies. As a result, interim nutrient goals are proposed together with an adaptive management strategy to revise them as new data become available.
The Solution:	A watershed-scale strategy which takes full advantage of both point and non-point source controls in a coordinated fashion is essential to reduce nutrient loads to the maximum extent possible.

Technical reports prepared in support of the nutrient overview presented in this section of Volume II include:

- ***Appendix A*** *– Total Maximum Daily Loads (TMDL) Summary*
- ***Appendix B*** *– DEQ and EPA Response to Public Comments Received on the February 28, 2005 Volume I Document*
- ***Appendix C*** *– GWLF/BATHTUB Modeling Results*
- ***Appendix E*** *– Permitted Point Source Discharges*
- ***Appendix H*** *– Supplemental Monitoring and Assessment Strategy*
- ***Appendix I*** *– Phased Wasteload Allocation Strategy*
- ***Appendix J*** *– Wasteload Allocations for Regulated Stormwater Discharges*
- ***Appendix K*** *– On-Site Domestic Wastewater Treatment in the Lake Helena Watershed*

3.2.1 The Nutrient Problem and Water Bodies of Concern

The nutrients nitrogen and phosphorus are essential for plant and animal growth and nourishment, but an over abundance of certain nutrients in water can cause a number of adverse health and ecological effects. Cultural eutrophication is a process whereby lakes, reservoirs, estuaries, and slowly moving rivers react to the effects of excessive nutrient loading. Symptoms may include nuisance levels of plant growth (attached and free living algae and rooted higher plants), reduced nighttime and wintertime dissolved oxygen concentrations and related fish kills, water taste and odor problems, reduced aesthetics and recreation, clogged water intakes, and others.

Based on the analyses that were presented in the Lake Helena watershed Volume I report, nutrient problems currently exist in the water bodies listed below and shown in Figure 3-3.

- Prickly Pear Creek (MT411006_030)
- Prickly Pear Creek (MT411006_020)
- Sevenmile Creek (MT411006_160)
- Spring Creek (MT411006_080)
- Tenmile Creek (MT411006_143)
- Lake Helena (MT411007_010)

In general, high in-stream nutrient concentrations, nuisance levels of algae, and low dissolved oxygen concentrations have been documented in these water bodies. Volume I provided details regarding the degree of impairment and how the impairments are manifested in each of the water bodies. Additionally, if no actions are taken to curb nutrient loading and population growth continues to increase at projected rates within the watershed, total nitrogen (TN) and total phosphorus (TP) loading to Lake Helena is estimated to increase by 43 and 78 percent, respectively, in the foreseeable future (see Appendix C).

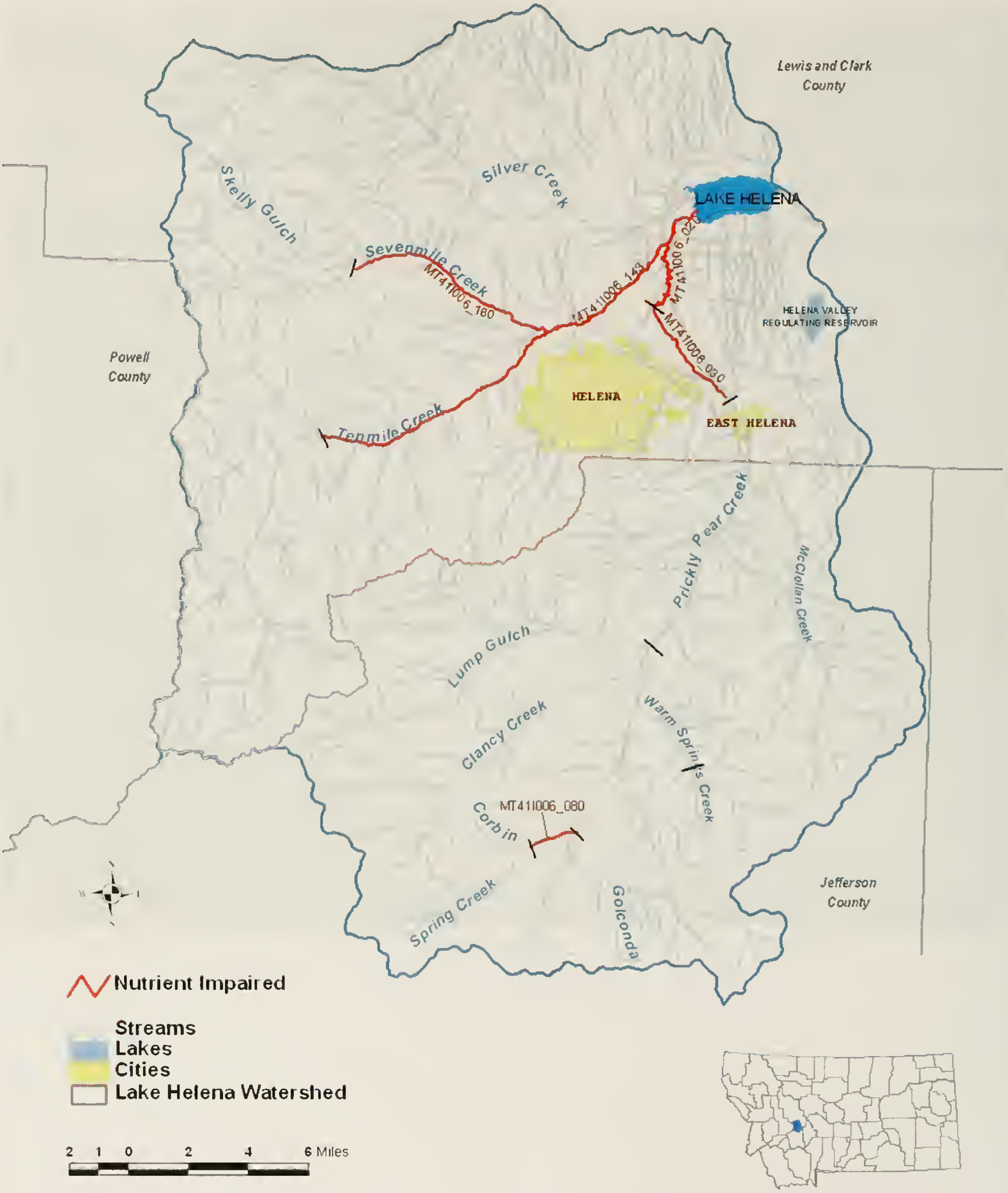


Figure 3-3. Nutrient impaired water bodies in the Lake Helena watershed.

3.2.2 Nutrient Sources

The GWLF model was used to estimate the relative importance of nutrient loading from each of the nutrient source categories listed in Table 3-3 (see Appendix C for a detailed account of the nutrient modeling process and definitions of source categories). Since nothing can be done to control loading from the natural sources listed in Table 3-3, they are not discussed further.

Table 3-3. Nutrient source categories considered in this analysis.

Category	Source
Point Sources	City of Helena WWTP (pre- and post-upgrades), East Helena WWTP, Evergreen Nursing Facility, Treasure State Acres, Tenmile and Pleasant Valley subdivisions, Montana Law Enforcement Academy, Fort Harrison
Anthropogenic Non-point Sources	Timber harvest, unpaved roads, non-system roads, paved roads, active mines and quarries, abandoned mines, agriculture, urban areas (includes permitted and unpermitted stormwater), anthropogenic streambank erosion, Helena Valley Irrigation District, groundwater, individual septic systems
Natural Non-point Sources	Forest, wetlands, shrubland, grassland, natural streambank erosion

The relative importance of the various nitrogen and phosphorus sources in the Lake Helena watershed is shown in Figure 3-4 and Figure 3-5. The estimates of source loading were made using the best available data and tools, but it is recognized that there is considerable uncertainty inherent within a source quantification effort such as this. For example, only one weather station (Helena Airport) was available to estimate precipitation throughout the entire watershed area. Although elevation effects on precipitation and temperature were accounted for on a sub-watershed scale, the weather patterns are more variable in the valley compared to the upper elevations and therefore streamflow is under-predicted in dry years and over-predicted in wet years. Other areas of uncertainty include: estimate of timber harvest on private land, fate and transport of wastewater treatment plant nutrient loads, proportion of failing septic systems, and soil nutrient concentrations. Despite this uncertainty, the results are believed to be reasonable and appropriate for development of a framework TMDL when coupled with the adaptive management strategy provided in Section 3.2.3.1 .

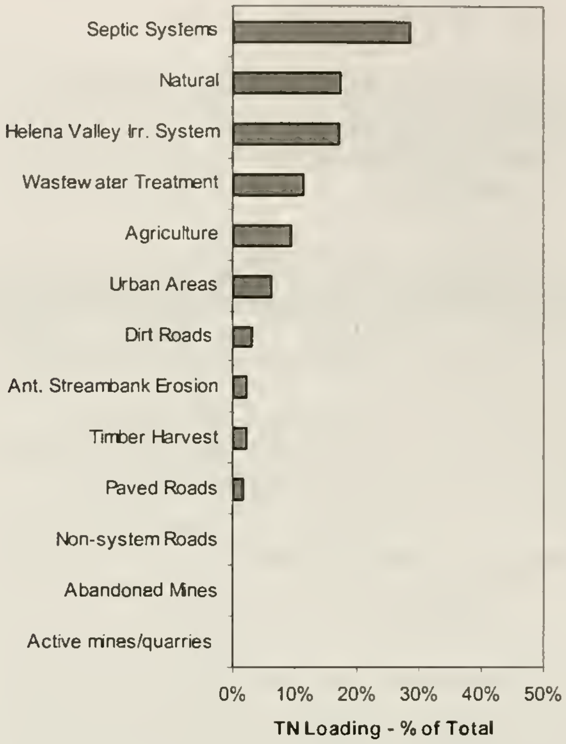


Figure 3-4. Estimated total nitrogen (TN) loading in the Lake Helena watershed by source category.

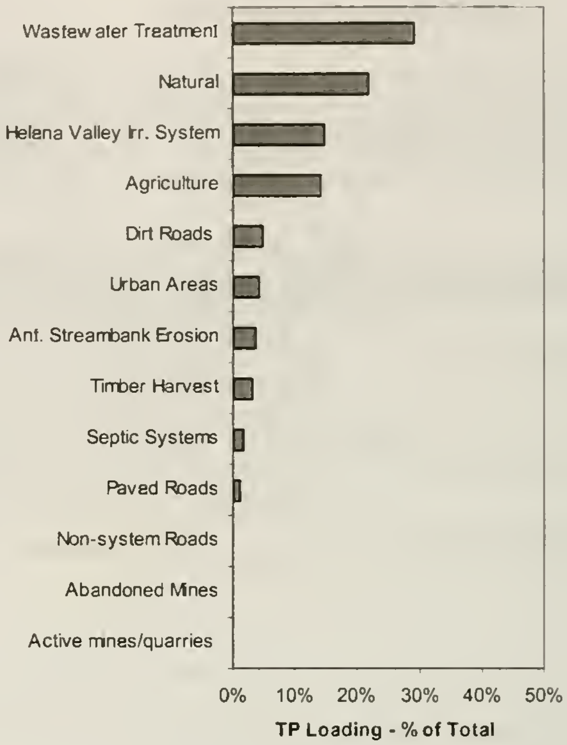


Figure 3-5. Estimated total phosphorus (TP) loading in the Lake Helena watershed by source category.

At the watershed scale (i.e., the entire Lake Helena watershed), septic systems (29 percent), return flows from the Helena Valley Irrigation District (17 percent), municipal wastewater treatment (WWTP) facilities (11 percent), and urban areas (6 percent) comprise the most significant sources of total nitrogen (TN). For total phosphorus (TP), municipal wastewater treatment facilities (28 percent), return flows from the Helena Valley Irrigation District (15 percent), agriculture (14 percent), unpaved roads (5 percent), and urban areas (4 percent) comprise the most significant sources.

The individual streams considered impaired due to nutrients (Spring Creek, Tenmile Creek, Sevenmile Creek, and Prickly Pear Creek) are all within the Prickly Pear Creek sub-watershed. The relative importance of the various nutrient sources within the Prickly Pear Creek sub-watershed is shown in Figures 3-6 and 3-7. Discharges of both TN and TP from municipal wastewater treatment facilities are far more important at the scale of the Prickly Pear Creek sub-watershed than they are at the scale of the entire Lake Helena watershed. For example, the municipal wastewater treatment facilities are the largest contributors of both TN and TP to Prickly Pear Creek and have the greatest impact in the most downstream segment (i.e., downstream of the City of Helena WWTP). For TN, septic systems, urban areas, and agriculture are the next most important sources. For TP, agriculture, unpaved roads, and streambank erosion are the next most significant sources. While the Helena Valley Irrigation District is one of the most significant sources of both TN and TP to Lake Helena, this source does not directly discharge to Prickly Pear Creek and therefore is not an important source at the sub-watershed scale.

The relative importance of the various TN and TP sources in the sub-watersheds of the remaining nutrient impaired streams is discussed in Appendix A.

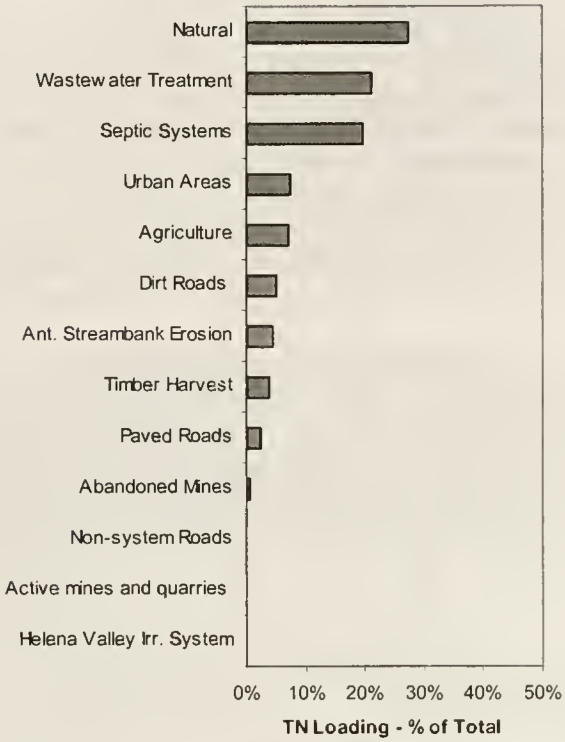


Figure 3-6. Estimated total nitrogen (TN) loading in the Prickly Pear Creek sub-watershed by source category.

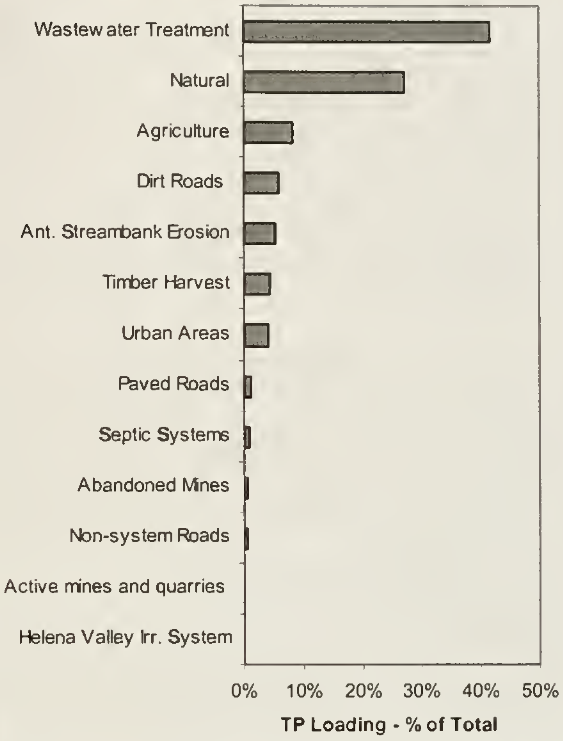


Figure 3-7. Estimated total phosphorus (TP) loading in the Prickly Pear Creek sub-watershed by source category.

3.2.3 Nutrient Goals

Similar to sediment, Montana's water quality standards for nutrients are narrative in form and must be interpreted to derive measurable (quantitative) water quality goals. A suite of measurable nutrient indicators was developed and described in Volume I to facilitate interpretation of the narrative nutrient standards for streams. This suite of indicators was selected based on the best data and information available when Volume I was completed. As a parallel but separate effort, Montana DEQ has been working on the development of numeric standards for nutrients and recently developed draft criteria. A comparison between the various potential nutrient criteria is presented in Table 3-4. Overall, the analysis shows that the candidate values are all relatively similar.

Table 3-4. Alternative nutrient water quality endpoints for Lake Helena watershed streams.

Parameter	Values Proposed in Volume I (year round)	Draft MDEQ Summer Values[1]		Draft MDEQ Year-round Values	
		75th Percentile	90th Percentile	75th Percentile	90th Percentile
Total Nitrogen (mg/l)	0.34	0.32	0.33	0.27	0.33
Total Phosphorus (mg/l)	0.027	0.01	0.02	0.02	0.04
Benthic Chlorophyll a (mg/m^2)	37	23.36	45.95	22.97	45.95

[1] *The values in these columns represent statistical summaries of nitrogen and phosphorus concentrations and benthic algal chlorophyll a densities for reference streams in the Middle Rockies Ecoregion (ICF, 2005).*

Both sets of values (those presented in Volume I and those developed by MDEQ) were developed using a reference-based approach based on U.S. EPA's recommended methodology U.S. EPA, in their Nutrient Criteria Technical Guidance Manual (USEPA, 2000), suggests that the 75th percentile value from a large reference data set can be used to establish criteria. The year-round nutrient targets presented in Volume I and the MDEQ 75th percentile values are nearly identical. Given that they were derived using independent methods provides additional confidence in the values. However, with the historic landscape scale changes that have occurred in the Lake Helena watershed over the last 150 years (see Section 3.0), it is acknowledged that it may not be technically or economically feasible to attain these nutrient values. For example, the TN and TP loads would need to be reduced by approximately 80 and 87 percent, respectively, to achieve the least restrictive values presented in Table 3-4.

Final nutrient targets are not presented at this time because of the uncertainties described above. Instead, interim nutrient targets are proposed for the Lake Helena watershed streams in combination with an adaptive management strategy that will allow for target revision in the future. The draft MDEQ 90th year-round percentile values presented in Table 3-4 are proposed as the interim targets. It is felt that these targets are based on the best available data and provide the best means by which to ensure protection of beneficial uses until such time as they can be revised following the adaptive management strategy presented below.

No nutrient concentration targets are presented for Lake Helena at this time due to limited historical water quality data and an incomplete understanding of the hydrologic relationship between Lake Helena and Hauser Reservoir (see Appendix A and Appendix B). Interim nutrient loading goals, however, are proposed in Section 3.2.4.

3.2.3.1 Adaptive Management Applied to the Nutrient Targets

An adaptive management strategy is proposed to facilitate revision of the nutrient threshold values for the streams in the Lake Helena watershed and to derive threshold values for Lake Helena (and possibly Hauser Reservoir). This strategy combines and coordinates supplemental study elements with regulatory elements.

3.2.3.2 Supplemental Study Elements

The supplemental study elements include both additional monitoring and modeling. A detailed monitoring strategy (outlined in Appendix H) is proposed to:

- Better characterize current water quality conditions in Prickly Pear Creek, Lake Helena and Hauser Reservoir;
- Compile sufficient data for future model calibration;
- Develop an understanding of the relationship between nutrient loading and stream/lake response (i.e., what is the threshold above which beneficial uses are impaired); and
- Develop an understanding of the hydrologic connection between Lake Helena, the Causeway Arm of Hauser Reservoir, and Hauser Reservoir as a whole.

Additional modeling is also proposed to allow for a more direct understanding of the link between in-stream nutrient concentrations, environmental variables, and biotic response. The current GWLF and BATHTUB models have been set up at a relatively coarse scale to provide information at the annual or monthly time period (see Appendix C). Daily and/or even hourly simulations are required to observe water body response to nutrients. The LSPC model has already been set up at the watershed scale to address metals issues (see Section 3.3 and Appendix F) and has the capability of simulating finer time steps and algal response in streams assuming sufficient calibration data are available. For example, LSPC could be used to simulate hourly dissolved oxygen concentrations to determine how reduced benthic algae would lead to higher dissolved oxygen minimums. With this in mind, it is recommended that future activities for lower Prickly Pear Creek involve additional sampling and data collection to facilitate use of the LSPC model to further evaluate nutrient issues.

EPA/MDEQ propose to initiate the supplemental study elements in 2006, contingent upon availability of funding and appropriate resources.

Adaptive Management Strategy for Nutrients

The adaptive management strategy for nutrients has been developed to refine our understanding of the relationship between nutrient loading and impacts to beneficial uses in the streams and lakes in the Lake Helena watershed. Once the supplemental study elements presented in Section 3.2.3.2 are completed, sufficient data and information will be available to determine the nutrient threshold above which beneficial uses would be impacted in the streams and lakes (the science). The alternatives analysis/feasibility study to be conducted by the point source nutrient dischargers will determine the maximum level of treatment that can be provided through wastewater treatment and the associated costs (technology and economics).

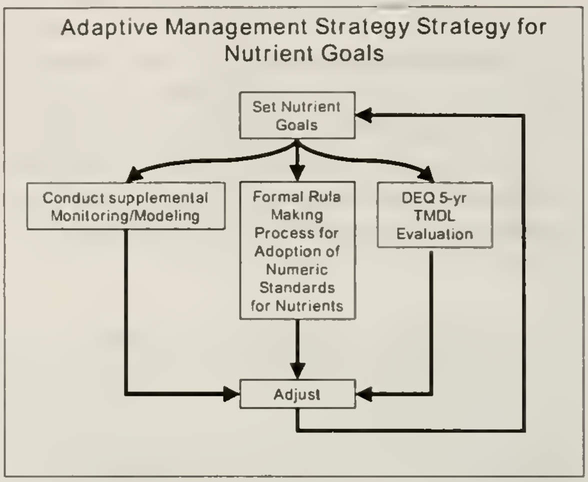
Concurrent with the above elements, Montana has begun the process to develop and adopt statewide numeric nutrient standards. Montana's process will ultimately unfold as a formal rule making process including scientific, technological, and economic analyses, public involvement and comment, and review and action by the Montana Board of Environmental Review.

At the scale of the Lake Helena watershed, the "scientific" and "technological/economic" information complied through the supplemental studies and alternatives analysis conducted by point source dischargers will be factored into the State's formal rule making process to adopt numeric standards for nutrients that would be applicable to the Lake Helena watershed.

Once the numeric standards are adopted, the interim targets presented in this document will be revised to reflect them. Further, the plans for reducing both point source and non-point source nutrient loads will also be revised to reflect them.

3.2.3.3 Regulatory Elements

There are two primary regulatory mechanisms through which water quality targets and TMDLs may be modified in the future, as follows: 1) Montana Code Annotated 75-5-703(9)(c) provides a provision for revising the TMDL based on an evaluation conducted by MDEQ five years after the TMDL is completed and approved, and 2) MDEQ has begun the initial steps of numeric standards development for nutrients. MDEQ expects to start the formal rule making process for adoption of numeric standards within the next two years. Prior to the start of formal rulemaking, MDEQ will provide opportunity for informal public comment, as well as for the formal public comment prescribed under statute.


Adaptive Management Strategy Strategy for Nutrient Goals
Set Nutrient Goals
Conduct supplemental Monitoring/Modeling
Formal Rule Making Process for Adoption of Numeric Standards for Nutrients
DEQ 5-yr TMDL Evaluation
Adjust

The current "use classification" for lower Prickly Pear Creek drives the final adaptive management element relative to nutrients. Prickly Pear Creek from Highway 433 to Lake Helena is currently classified as an "I" stream. Streams classified as "I" are not currently supporting all of their designated uses, but ultimate attainment of these uses is the goal of the State of Montana. The ultimate goal for Prickly Pear Creek is to attain full support of all of the designated uses associated with the underlying use classification for the remainder of the stream (i.e., B-1).

It is envisioned that the above elements together will provide the needed data and information to revise the proposed nutrient targets, if necessary, and to provide a regulatory and public involvement framework through which the revisions could be made.

3.2.4 The Solution

The solution to the nutrient problem is to immediately begin reducing nutrient loads from all sources, both point and non-point, in the Prickly Pear, Tenmile, Sevenmile, Spring Creek, and Lake Helena sub-watersheds. The necessary nutrient load reductions for these water bodies, based on the interim targets, are shown in Table 3-5. Since no concentration targets have been proposed for Lake Helena at this time, it is assumed that the load reductions for Prickly Pear Creek (the largest tributary to Lake Helena) will sufficiently address the load reduction needs for Lake Helena. TMDLs have been prepared for each of these water bodies and the required load reductions for each contributing source are presented in Appendix A.

The proposed approach acknowledges that it may be necessary to revise the nutrient concentration goals in the future and it provides an adaptive management strategy to revise them. It is also acknowledges that beneficial uses are already impaired and conditions are predicted to deteriorate further if nothing is done to curb present rates of nutrient loading.

Table 3-5. Current Lake Helena watershed nutrient loads and required reductions.

Watershed	Estimated Total Nitrogen Load (tons/yr)	Reduction Required to meet 0.33 mg/l Total Nitrogen Goal	Estimated Total Phosphorus Load (tons/yr)	Reduction Required to meet 0.04 mg/l Total Phosphorus Goal
Prickly Pear Creek	186.1	80	35.5	87
Sevenmile Creek	15.4	65	2.3	79
Spring Creek	7.5	75	1.3	83
Tenmile Creek	57.0	59	7.1	61
Lake Helena	353.4	80[1]	51.2	87[1]

[1] In the absence of appropriate water quality targets for Lake Helena, the load reductions for Prickly Pear Creek (the largest tributary watershed to Lake Helena) are assumed to be sufficient to address nutrient impairment issues in Lake Helena.

A phased approach, focusing on both non-point and point sources is proposed. As shown in Figure 3-8, the proposed approach has been coordinated, in time, with point source discharge permit renewals and the rulemaking procedure for adoption of numeric standards for nutrients. This approach combines elements described previously in the main document and in various appendices. Table 3-6 provides a list of each of the steps in this approach and references to detailed descriptions of each of the activities.

Table 3-6. Proposed chronology of point and non-point source nutrient control activities.

Year	Implementation Activity	Description
2006	Complete and approve TMDLs and establish interim nutrient targets	See Section 3.2.3
	Implement supplemental monitoring/modeling studies	See Section 3.2.3.1
	Implement voluntary non-point source controls	See Appendix A for source specific load reductions and Section 4.0
	Implement voluntary point source monitoring	See Appendix I
	Implement voluntary point source optimization and feasibility studies	See Appendix I
	Implement voluntary Phase I point source controls	See Appendix I
	MDEQ technical analyses in support of nutrient standards development	See Section 3.2.3.1
	Initiate formal rule making process to adopt numeric nutrient standards	See Section 3.2.3.1
2008	MBER adopts numeric nutrient standards	See Section 3.2.3.1
	Revise TMDL and targets to incorporate numeric nutrient standards	Once numeric nutrient standards are officially adopted, the nutrient TMDLs and targets will be revised.
2009	MDEQ renews MPDES permits for Helena and East Helena WWTPs	See Appendix I
	Implement Phase II point source controls based on optimization study results	See Appendix I
2014	MDEQ renews MPDES permits for Helena and East Helena	See Appendix I
	Implement Phase III point source controls based on numeric nutrient standards and results of feasibility study	See Appendix I

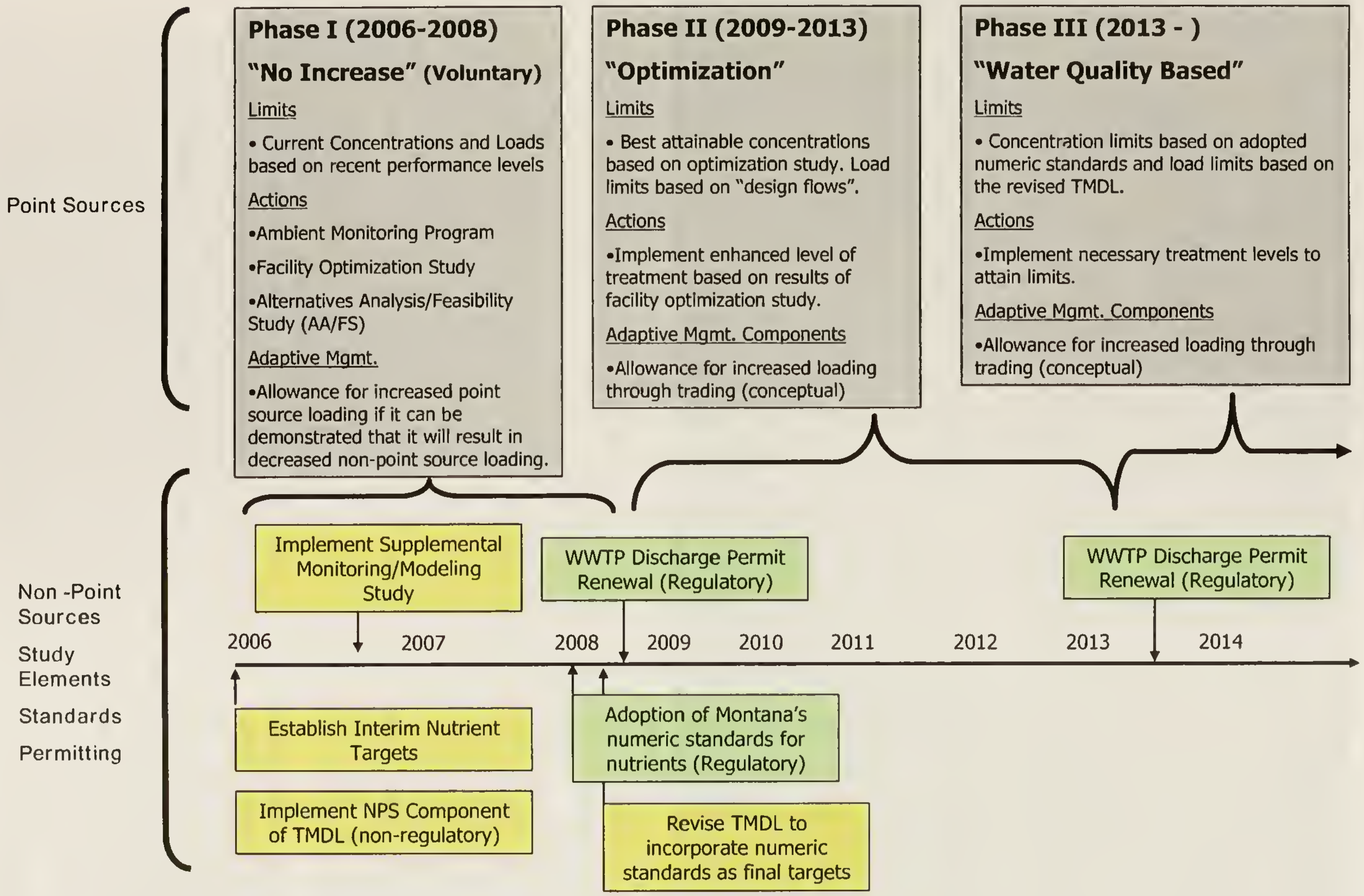

Point Sources
Phase I (2006-2008)
"No Increase" (Voluntary)
Limits
• Current Concentrations and Loads based on recent performance levels
Actions
•Ambient Monitoring Program
•Facility Optimization Study
•Alternatives Analysis/Feasibility Study (AA/FS)
Adaptive Mgmt.
•Allowance for increased point source loading if it can be demonstrated that it will result in decreased non-point source loading.
Phase II (2009-2013)
"Optimization"
Limits
• Best attainable concentrations based on optimization study. Load limits based on "design flows".
Actions
•Implement enhanced level of treatment based on results of facility optimization study.
Adaptive Mgmt. Components
•Allowance for increased loading through trading (conceptual)
Phase III (2013 -)
"Water Quality Based"
Limits
• Concentration limits based on adopted numeric standards and load limits based on the revised TMDL.
Actions
•Implement necessary treatment levels to attain limits.
Adaptive Mgmt. Components
•Allowance for increased loading through trading (conceptual)
Non -Point Sources
Study Elements
Standards
Permitting
Implement Supplemental Monitoring/Modeling Study
WWTP Discharge Permit Renewal (Regulatory)
WWTP Discharge Permit Renewal (Regulatory)
2006
2007
2008
2009
2010
2011
2012
2013
2014
Establish Interim Nutrient Targets
Implement NPS Component of TMDL (non-regulatory)
Adoption of Montana's numeric standards for nutrients (Regulatory)
Revise TMDL to incorporate numeric standards as final targets

Figure 3-8. Proposed chronology of point and non-point source nutrient control activities.

3.3 METALS

The Problem:	High in-stream concentrations of certain metals (e.g., arsenic, cadmium, copper, lead, and zinc) exceed levels that are considered protective of aquatic life and/or human health. Streambed sediment and fish tissue metals concentrations are also elevated in certain parts of the watershed.
Water Bodies of Concern:	Clancy Creek, Corbin Creek, Golconda Creek, Jennies Fork, Lump Gulch, Middle Fork Warm Springs Creek, North Fork Warm Springs Creek, Prickly Pear Creek, Tenmile Creek, and Warm Springs Creek.
The Source:	Mining and mine drainage, particularly from abandoned mines, are considered to be the primary source of metals within the watershed. Metals are also associated with the erosion of sediments from other sources.
In-Stream Metals Goals:	Achieve numeric criteria established in water quality standards.
The Solution:	A watershed scale strategy that incorporates both point and non-point source reductions to achieve water quality standards in all water bodies in the Lake Helena watershed.

Technical reports prepared in support of the metals overview presented in this section of Volume II include:

- ***Appendix A*** *– Total Maximum Daily Load (TMDL) Summary*
- ***Appendix E*** *– Permitted Point Source Discharges*
- ***Appendix F*** *– LSPC Metals Modeling Results*
- ***Appendix H*** *– Supplemental Monitoring and Assessment Strategy*

3.3.1 The Metals Problem and Water Bodies of Concern

Metals are naturally occurring in streams and lakes and originate from local geology, soils, and groundwater. Anthropogenic sources, such as industrial point sources, mines, mine drainage, soil erosion (from roads, agriculture, timber harvest, etc.), air deposition, and urban and road runoff can increase metal concentrations in streams to toxic levels. Numerous studies have shown that metals can be toxic to humans, fish, and aquatic life health at very low concentrations. Summaries of the toxic effects of six metals of concern – arsenic, cadmium, copper, lead, mercury, and zinc – are presented below (excerpted from *Information on the Toxic Effects of Various Chemicals and Groups of Chemicals,* USEPA, 2005).

- **Arsenic** – Arsenic is a carcinogen (cancer-causing), teratogen, and possible mutagen (causing mutations in genes/DNA) in mammals (ATSDR, 1993). Cancer-causing and genetic mutation-causing effects occur in aquatic organisms with those effects including behavioral impairments, growth reduction, appetite loss, and metabolic failure. Aquatic bottom feeders are more susceptible to arsenic.
- **Cadmium** – Cadmium is highly toxic to wildlife. It is cancer-causing and teratogenic, and potentially mutation-causing with severe sublethal and lethal effects at low environmental concentrations (Eisler, 1985a). It is associated with increased mortality, and it affects respiratory functions, enzyme levels, muscle contractions, growth reduction, and reproduction. It bioaccumulates at all trophic levels, accumulating in the livers and kidneys of fish (Sindayigaya et al., 1994; Sadiq, 1992). Crustaceans appear to be more sensitive to cadmium than fish and mollusks (Sadiq, 1992).
- **Copper** – Copper is highly toxic in aquatic environments and has effects in fish, invertebrates, and amphibians, with all three groups equally sensitive to chronic toxicity (USEPA, 1993; Horne and Dunson, 1995). Copper will bioconcentrate in many different organs in fish and mollusks (Owen, 1981). Single celled and filamentous algae and cyanobacteria are particularly susceptible to the acute effects of copper, which include reductions in photosynthesis and growth, loss of photosynthetic pigments, disruption of potassium regulation, and mortality. Sensitive algae may be affected by free copper at low parts per billion (ppb) concentrations in freshwater. There is a moderate potential for bioaccumulation in plants but no biomagnification.
- **Lead** – Lead is cancer-causing, and adversely effects reproduction, liver and thyroid function, and disease resistance (Eisler, 1988b). The main potential ecological impacts of wetland contamination from lead result from direct exposure of algae, benthic invertebrates, and embryos and fingerlings of freshwater fish and amphibians. It can be bioconcentrated from water but does not bioaccumulate and it tends to decrease with increasing trophic levels in freshwater habitats (Wong et al., 1978; Eisler, 1988b). Fish exposed to high levels of lead exhibit a wide-range of effects including muscular and neurological degeneration and destruction, growth inhibition, mortality, reproductive problems, and paralysis (Eisler, 1988b; USEPA, 1976). Lead adversely affects invertebrate reproduction and algal growth is affected.
- **Mercury** – Mercury is a mutagen, teratogen, and carcinogen, with toxicity and environmental effects varying with the form of mercury, dose, route of ingestion, and the exposed organism's species, sex, age, and general condition (Eisler, 1987a, Fimreite, 1979). There is a high potential for bioaccumulation and biomagnification with mercury, with biomagnified concentrations reported in fish up to 100,000 times the ambient water concentrations (Eisler, 1987a, Callahan et al., 1979). The primary targets of acute exposures are the central nervous system and kidneys in fish, birds and mammals. There are also effects on reproduction, growth, behavior, metabolism, blood chemistry, osmoregulation, and oxygen exchange at relatively low concentrations of mercury (Eisler, 1987a). Juveniles are commonly more susceptible than adults.
- **Zinc** – In many types of aquatic plants and animals, growth, survival, and reproduction can all be adversely affected by elevated zinc levels (Eisler, 1993). Zinc is toxic to plants at elevated levels,

causing adverse effects on growth, survival, and reproduction (Eisler, 1993). Terrestrial invertebrates show sensitivity to elevated zinc levels, with reduced survival, growth, and reproduction. Elevated zinc levels can cause mortality, pancreatic degradation, reduced growth, and decreased weight gain in birds (Eisler, 1993; NAS, 1980) and elevated zinc can cause a wide range of problems in mammals including cardiovascular, developmental, immunological, liver and kidney problems, neurological, hematological (blood problems), pancreatic, and reproductive (Eisler, 1993; Domingo,1994).

To protect beneficial uses from metals toxicity, Montana DEQ has set numeric water quality standards to protect against both acute and chronic exposure. Based on the analysis presented in Volume I, metals are currently exceeding the Montana DEQ water quality standards in thirteen stream segments and one lake in the Lake Helena watershed. The impaired segments include Clancy Creek, Corbin Creek, Golconda Creek, Jennies Fork, Lake Helena, Lump Gulch, Middle Fork Warm Springs Creek, North Fork Warm Springs Creek, Prickly Pear Creek, Sevenmile Creek, Silver Creek, Spring Creek, Tenmile Creek, and Warm Springs Creek (Figure 3-9). Table 3-7 lists the metals that are exceeding standards in each water body.

Table 3-7. Metals impaired water bodies in the Lake Helena watershed.

Water Body Name	Segment ID	Metals of Concern
Clancy Creek	MT41I006_120	Arsenic, Cadmium, Copper, Lead, Zinc
Corbin Creek	MT41I006_090	Arsenic, Cadmium, Copper, Lead, Zinc
Golconda Creek	MT41I006_070	Cadmium, Lead
Jennies Fork	MT41I006_210	Lead
Lake Helena	MT41I007_010	Arsenic, Lead
Lump Gulch	MT41I006_130	Cadmium, Copper, Lead, Zinc
Middle Fork Warm Springs Creek	MT41I006_100	Arsenic, Cadmium, Lead, Zinc
North Fork Warm Springs Creek	MT41I006_180	Arsenic, Cadmium, Zinc
Prickly Pear Creek	MT41I006_020	Arsenic, Cadmium, Lead
	MT41I006_030	Arsenic, Lead
	MT41I006_040	Arsenic, Cadmium, Copper, Lead, Zinc
	MT41I006_050	Cadmium, Lead, Zinc
	MT41I006_060	Lead
Sevenmile Creek	MT41I006_160	Copper, Lead, Arsenic
Silver Creek	MT41I006_150	Arsenic, Mercury
Spring Creek	MT41I006_080	Arsenic, Cadmium, Copper, Lead, Zinc
Tenmile Creek	MT41I006_141	Arsenic, Cadmium, Copper, Lead, Zinc
	MT41I006_142	Arsenic, Cadmium, Copper, Lead, Zinc
	MT41I006_143	Arsenic, Cadmium, Copper, Lead, Zinc
Warm Springs Creek	MT41I006_110	Arsenic, Cadmium, Lead, Zinc

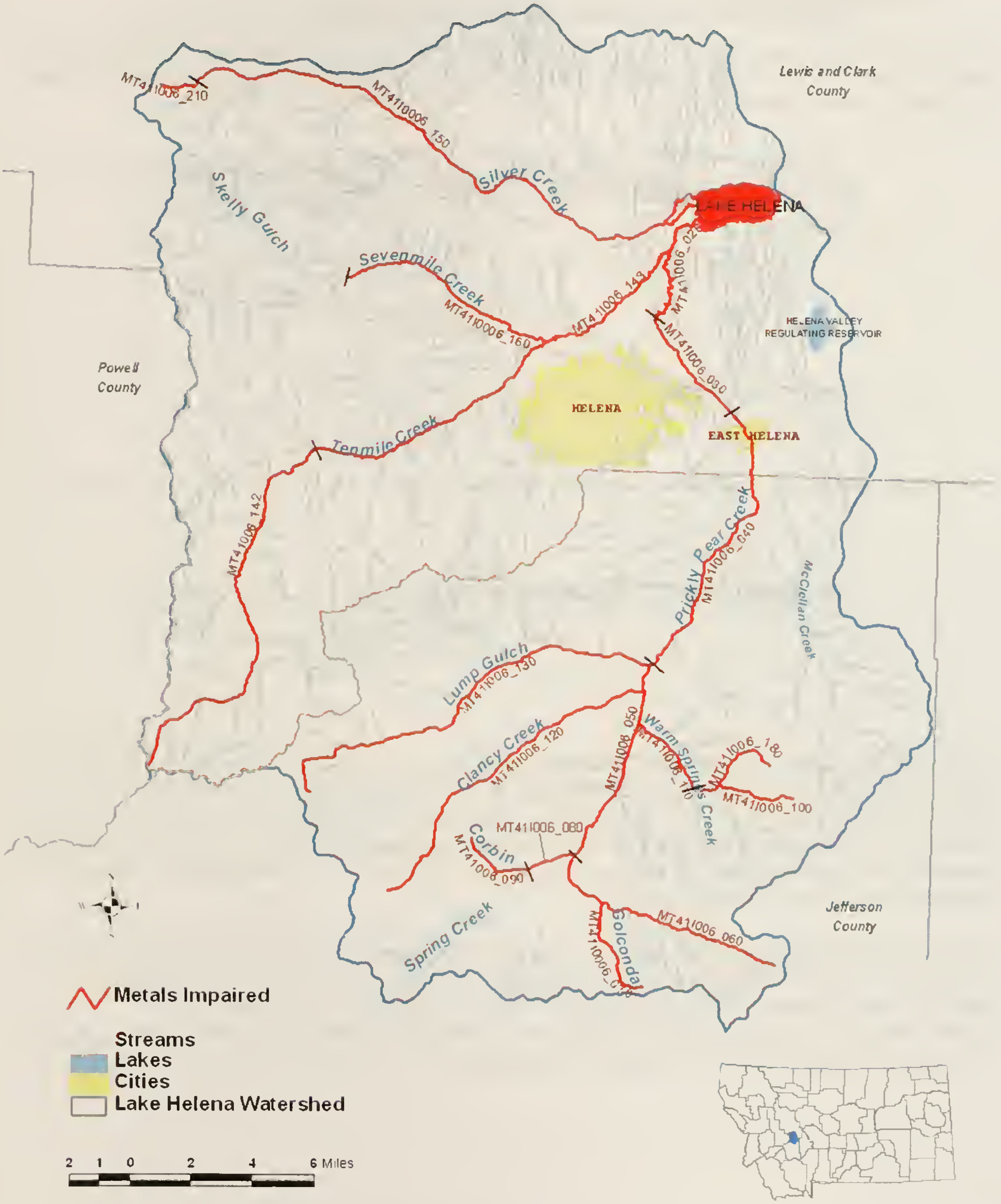


Figure 3-9. Metals impaired water bodies in the Lake Helena watershed.

3.3.2 Metals Sources

The LSPC model was used to estimate the relative importance of metals loading from each of the source categories listed in Table 3-8 (see Appendix F for a detailed account of the metals modeling process and definition of source categories).

Table 3-8. Metals source categories considered in this analysis.

Category	Source
Point Sources	MT Tunnels Mines
	ASARCO Smelter
Anthropogenic Non-point Sources	Abandoned Mines
	Anthropogenic Streambank Erosion
	Timber Harvest
	Unpaved Roads
	Non-system Roads
	Paved Roads
	Active mines and quarries
	Agriculture
	Urban Areas
Natural Non-point Sources	Forest
	Wetlands
	Shrubland
	Grassland
	Nat. Streambank Erosion

The relative importance of these source categories at the entire Lake Helena watershed scale is shown in Figures 3-10 to 3-14. The estimates of loading from each source category were made using the best available data and tools, but it is recognized that there is considerable uncertainty inherent within a source quantification effort such as this. Despite this uncertainty, the results are believed to be reasonable and appropriate for proceeding with development of a framework TMDL in combination with an adaptive management approach (see Appendix F).

At the time of this report, insufficient data were available to accurately quantify mercury loads in Silver, Clancy, Lump Gulch, Middle Fork Warm Springs, and Tenmile creeks. There are also limited fish and aquatic life data available to assess the potential impacts of historical mercury loading and bioaccumulation. Additional future monitoring is recommended to better address these loads, at which time the mercury TMDLs will be completed (Appendix H).

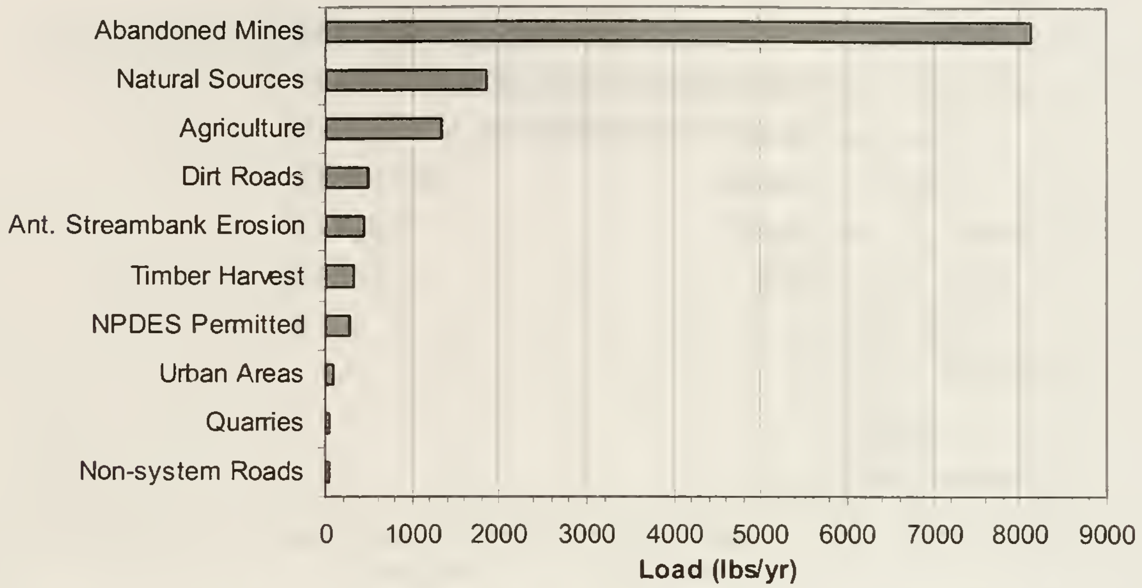


Figure 3-10. Estimated arsenic loading in the Lake Helena watershed by source category.

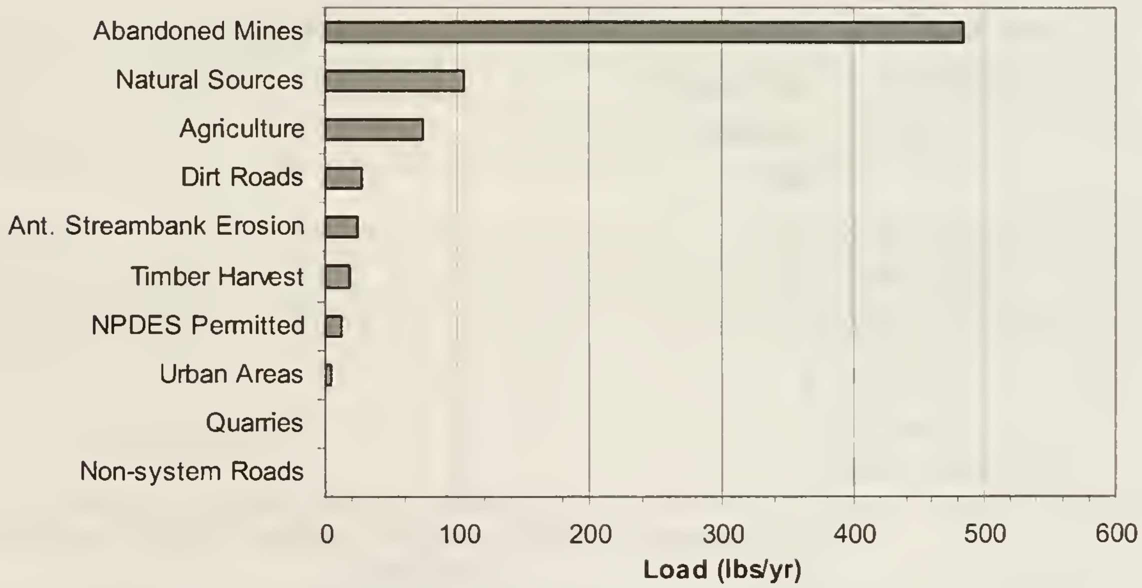


Figure 3-11. Estimated cadmium loading in the Lake Helena watershed by source category.

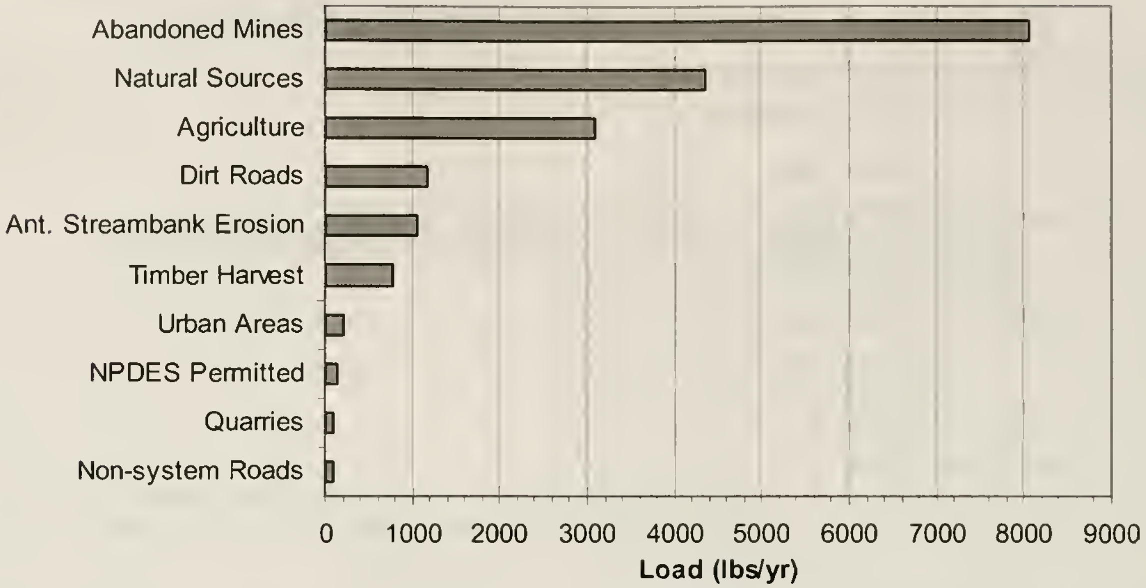


Figure 3-12. Estimated copper loading in the Lake Helena watershed by source category.

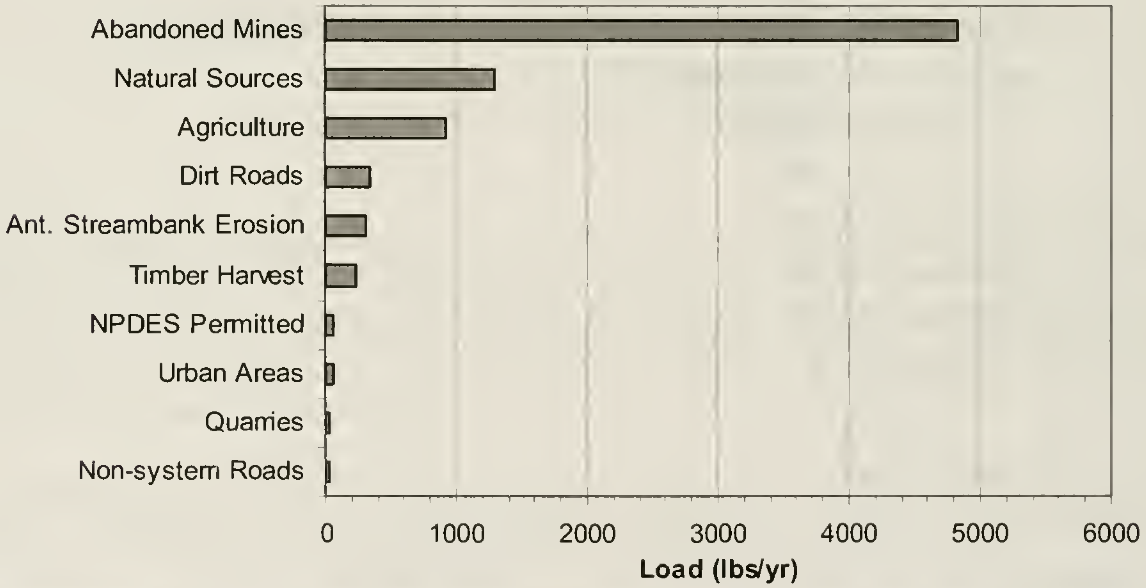


Figure 3-13. Estimated lead loading in the Lake Helena watershed by source category.

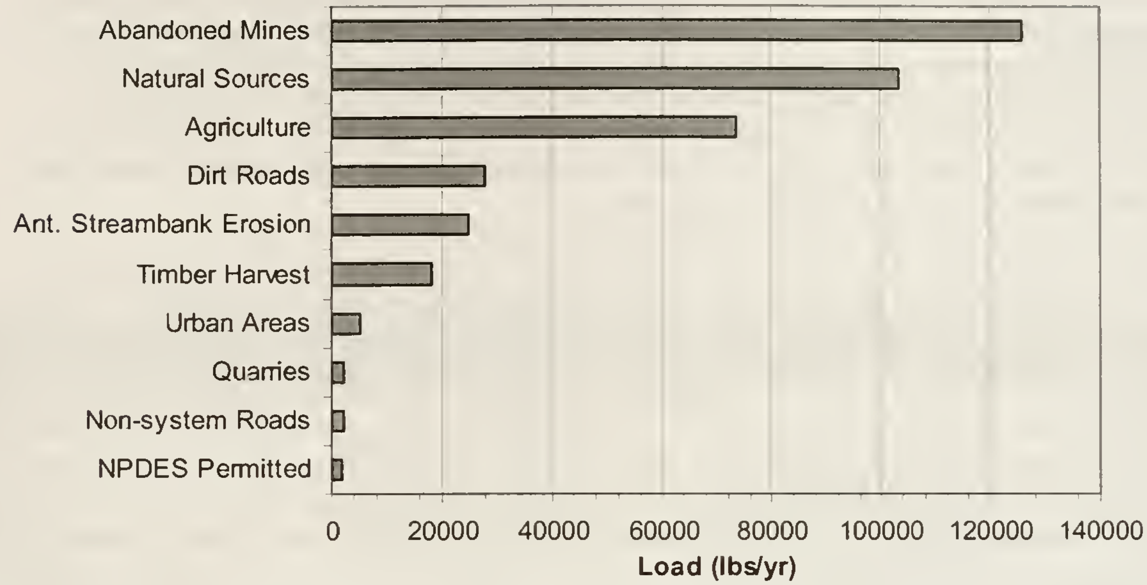


Figure 3-14. Estimated zinc loading in the Lake Helena watershed by source category.

At the watershed scale (i.e., the entire Lake Helena watershed), abandoned mines are the most significant source of metals loading. Natural sources (e.g., forest and grassland areas) and agriculture are the next most important sources, primarily because of the sediment derived metals they deliver to the streams. It should also be noted that agriculture is estimated to be a significant source of metals at the watershed scale due to the extensive agricultural areas in the Helena Valley, but not at the sub-watershed scale and closer to headwaters areas where most of the metals impairments are located.

The individual streams considered to be impaired due to metals are distributed throughout the watershed. Each of the three largest streams (Prickly Pear Creek, Tenmile Creek, and Sevenmile Creek) is impaired, as are various tributaries. Abandoned mining is estimated to be the most significant source of metals for each listed water body. The relative importance of the various metals sources in the sub-watersheds is discussed in Appendix A.

3.3.3 Metals Goals

Unlike sediment and nutrients, Montana's water quality standards for metals are numeric and therefore can be directly applied as water quality goals in the development of TMDLs.

The *Circular WQB-7, Montana Numeric Water Quality Standards* contains numeric water quality standards for Montana's surface water and groundwater. The standards in Circular WQB-7 are set at the levels necessary to protect the designated uses of all surface waters of the state. They are based on the best available scientific evidence relating the concentration of pollutants to effects on aquatic life and human health. These numeric standards are used as TMDL targets for metals.

There are three numeric standards for each metal: acute and chronic toxicity aquatic life standards designed to protect designated aquatic life uses, and the human health standard which is designed to protect drinking water uses[1]. Table 3-9 shows the acute and chronic aquatic life standards and the human health standards that apply to the metals of concern in the Lake Helena watershed. Both the acute and chronic aquatic life standards for cadmium, copper, lead, and zinc are water hardness dependent. The criteria are calculated using the formulas found in Montana DEQ Circular WQB-7. An average water hardness for each impaired stream segment was determined from the available data and used to identify the appropriate metals concentration target for TMDL development. The average hardness and resulting metals concentration targets are presented in Appendix A.

Table 3-9. Montana numeric surface water quality standards for metals.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10
Cadmium (TR)	1.05 at 50 mg/L hardness[c]	0.16 at 50 mg/L hardness[c]	5
Copper (TR)	7.3 at 50 mg/L hardness[c]	5.2 at 50 mg/L hardness[c]	1,300
Lead (TR)	82 at 100 mg/L hardness[c]	3.2 at 100 mg/L hardness[c]	15
Zinc (TR)	67 at 50 mg/L hardness[c]	67 at 50 mg/L hardness[c]	2,000

Note: TR = total recoverable analysis method.
[a] Maximum allowable concentration.
[b] No 4-day (96-hour) or longer period average concentration may exceed these values.
[c] The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L) (see Montana DEQ Circular WQB-7 for the coefficients to calculate the standard).

3.3.4 The Solution

The solution to the metals impairments is to reduce metals loading throughout the Lake Helena watershed. The following steps were taken to determine the load reductions necessary to meet each component of the metals water quality standards:

1) Loads from NPDES permitted-facilities were input to the LSPC model at their allowable permit limits (see Appendix F). This was done to account for allowable loads even though a facility's loads might actually be significantly less than their allowable load.
2) Expected reductions of sediment adsorbed metals were input to the LSPC model for each relevant source category to account for the reductions resulting from the sediment TMDLs (see Section 3.1). The percentage reductions were assumed to be the same for sediment and sediment adsorbed metals.
3) Additional reductions were modeled for the abandoned mines source category until all three numeric standards for each metal were met. Loads were reduced until no predicted daily value exceeded the acute aquatic life or human health criteria and no 4-day average exceeded the chronic aquatic life criteria. There was no single criterion that drove all the reductions. The exception was arsenic, for which the human health criterion was the driving factor.

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[1] It should be noted that recent studies have indicated some metals concentrations vary through out the day because of diel pH and alkalinity changes (USGS, 2003). In some cases the variation can cross the standard threshold (both ways) for a metal. Montana water quality standards are not presently time-of-day dependent.

4) It is recognized that the Montana Tunnels Mine (NPDES Permit MT0028428) rarely if ever discharges to Spring Creek. However, the TMDLs presented in this document and in Appendix A are based on the permitted flows and pollutants for all point source discharges. The Montana Tunnels Mine arsenic permit limit (290 µg/L) is currently 29 times larger than the new arsenic human health criterion (10 µg/L). To meet water quality standards in Spring Creek, the permitted arsenic load was reduced by 60 percent.

An upstream to downstream approach was used to develop the TMDL allocations. Impaired headwaters were analyzed first, because their impact frequently had a profound effect on downstream water quality. Loading contributions were reduced from all relevant sources for these water bodies and model results from the selected scenarios were then routed through downstream water bodies. Therefore, when TMDLs were developed for downstream impaired water bodies, upstream loading reductions capable of meeting water quality standards in those upper segments were included.

TMDLs for each of the metals impaired water bodies and the source specific load reductions are presented in Appendix A. A summary of the load reductions for each water body is presented in Table 3-10. Figures 3-15 to 3-19 show the necessary load reductions by source category for the entire Lake Helena watershed.

The expected load reductions from most source categories (e.g., anthropogenic streambank erosion, timber harvest) was based on the anticipated reductions accruing from the sediment TMDLs (see Section 3.1). Additional load reductions from abandoned mine cleanup activities ranged from 70 to 90 percent depending on the stream and metal. It is not yet certain whether this level of treatment for abandoned mines will be attainable for all impaired streams. Pre- and post-reclamation monitoring of a semi-passive treatment system at the Lee Mountain Mine in upper Tenmile Creek indicates removal efficiencies as high as 90 percent are possible (personal communication, Mike Bishop, U.S, EPA Superfund Program, 2005). However, it might be prohibitively expensive or practically impossible to achieve this level of treatment at all sites.

In some cases, alternative remedies might also be needed in addition to reducing loads from abandoned mines. For example, one restoration strategy under consideration for Upper Tenmile Creek is to decrease the City of Helena's reliance on Tenmile Creek water for its municipal supply. By diverting less water, in-stream flows would be increased essentially helping to dilute metals concentrations. A site-specific modeling analysis of upper Tenmile Creek indicates that a one to three cubic feet per second increase in streamflows during critical low flow conditions would greatly increase the likelihood that water quality standards could be met (Caruso, 2004).

Table 3-10. Current Lake Helena watershed metals loads and required reductions.

Segment	Metal	Existing Load (lbs/yr)	Load Reduction (%)	Total Allowable Load (lbs/yr)
Clancy Creek (MT41I006_120)	Arsenic	717.9	61.1%	279.3
	Cadmium	34.0	61.2%	13.2
	Copper	897.0	42.3%	517.6
	Lead	339.0	54.1%	155.6
	Zinc	20,038.9	47.0%	10,620.6
Corbin Creek (MT41I006_090)	Arsenic	48.4	24.7%	36.2
	Cadmium	87.7	96.8%	2.8
	Copper	1058.5	89.2%	114.6
	Lead	97.4	65.9%	33.2
	Zinc	58,393.2	97.2%	1,660.6
Golconda Creek (MT41I006_070)	Cadmium	1.1	40.9%	0.7
	Lead	27.2	76.9%	6.3
Jennies Fork (MT41I006_210)	Lead	15.5	45.7%	8.4
Lake Helena (MT41I007_010)	Arsenic	13,032.2	60.8%	5,104.2
	Lead	8,134.6	65.6%	2,798.0
Lump Gulch (MT41I006_130)	Cadmium	43.9	76.1%	10.4
	Copper	745.9	39.3%	452.8
	Lead	241.3	43.9%	135.3
	Zinc	26,599.2	68.1%	8,485.1
Middle Fork, North Fork, Main Stem Warm Springs Creek (MT41I006_100) (MT41I006_180)	Arsenic	472.8	58.7%	195.1
	Cadmium	14.3	61.9%	5.4
	Lead	102.5	31.6%	70.1
	Zinc	7,076.0	43.8%	3,976.7
Prickly Pear Creek (MT41I006_020) (MT41I006_030) (MT41I006_040) (MT41I006_050) (MT41I006_060)	Arsenic	9,497.9	58.5%	3,942.6
	Cadmium	652.1	73.8%	171.2
	Copper	14,200.1	58.0%	5,968.3
	Lead	6,627.9	68.6%	2,081.8
	Zinc	293,913.6	59.6%	118,623.5
Sevenmile Creek (MT41I006_160)	Arsenic	1,203.8	51.9%	578.7
	Copper	1,565.8	47.1%	828.0
	Lead	766.7	63.0%	283.8
Silver Creek (MT41I006_150)	Arsenic	2,752.5	64.6%	974.4
Spring Creek (MT41I006_080)	Arsenic	671.2	56.1%	294.6
	Cadmium	123.6	87.1%	15.9
	Copper	1,860.7	64.1%	668.0
	Lead	1,195.0	81.6%	219.8
	Zinc	74,792.8	80.7%	14,401.0
Tenmile Creek (MT41I006_141) (MT41I006_142) (MT41I006_143)	Arsenic	5,566.8	65.6%	1,912.6
	Cadmium	343.4	80.3%	67.6
	Copper	7,247.7	69.2%	2,232.4
	Lead	3,438.4	78.7%	734.1
	Zinc	96,844.7	54.9%	43,706.0

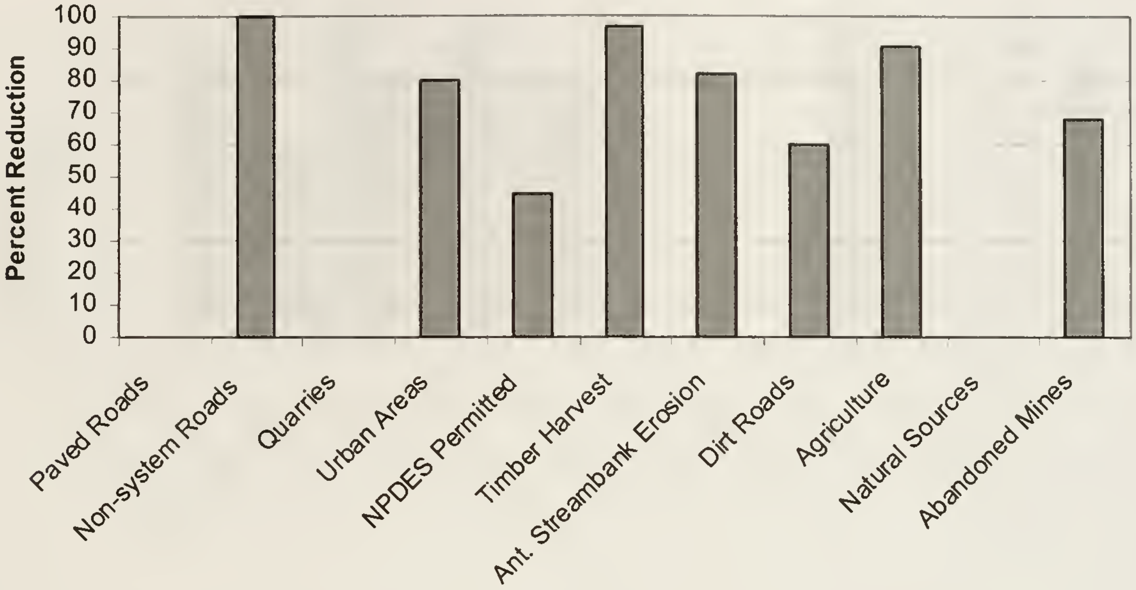

Figure 3-15. Percent reductions in arsenic loading by source category.

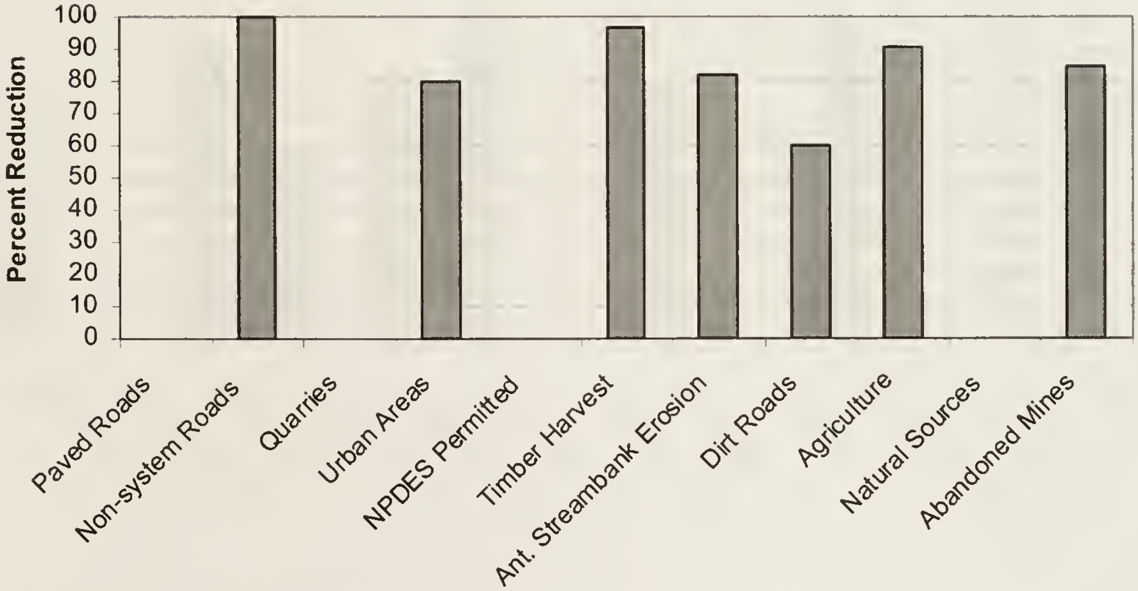

Figure 3-16. Percent reductions in cadmium loading by source category.

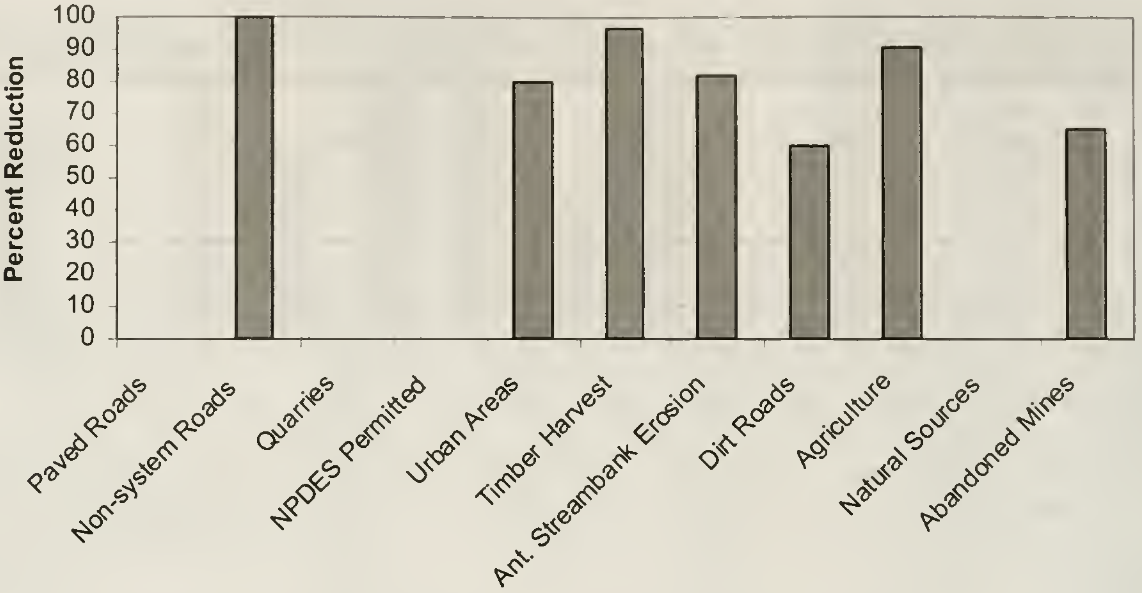

Figure 3-17. Percent reductions in copper loading by source category.

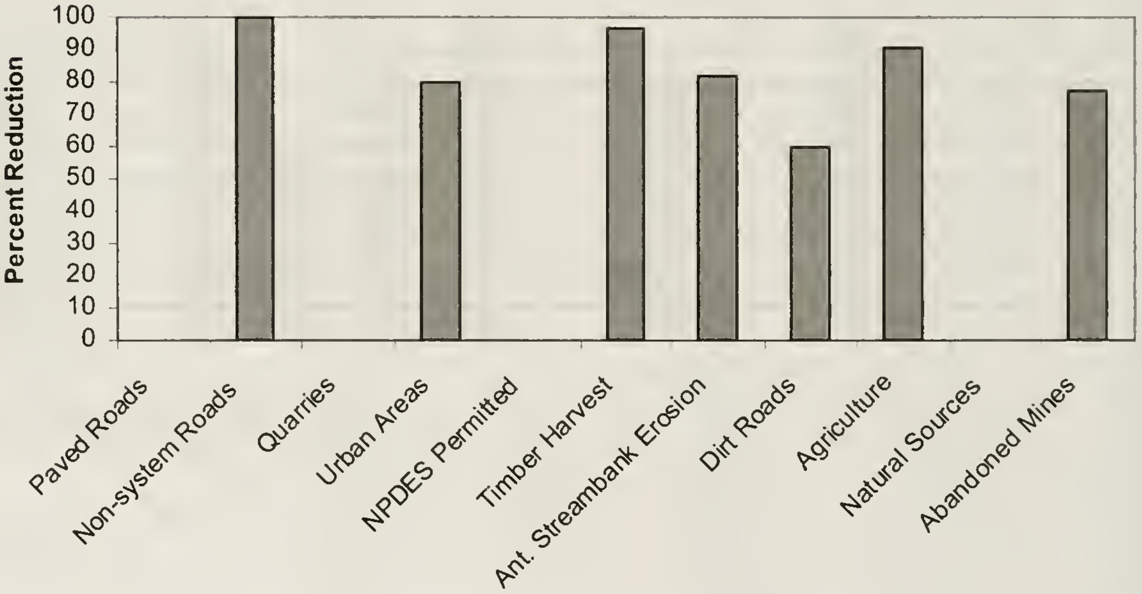

Figure 3-18. Percent reductions in lead loading by source category.

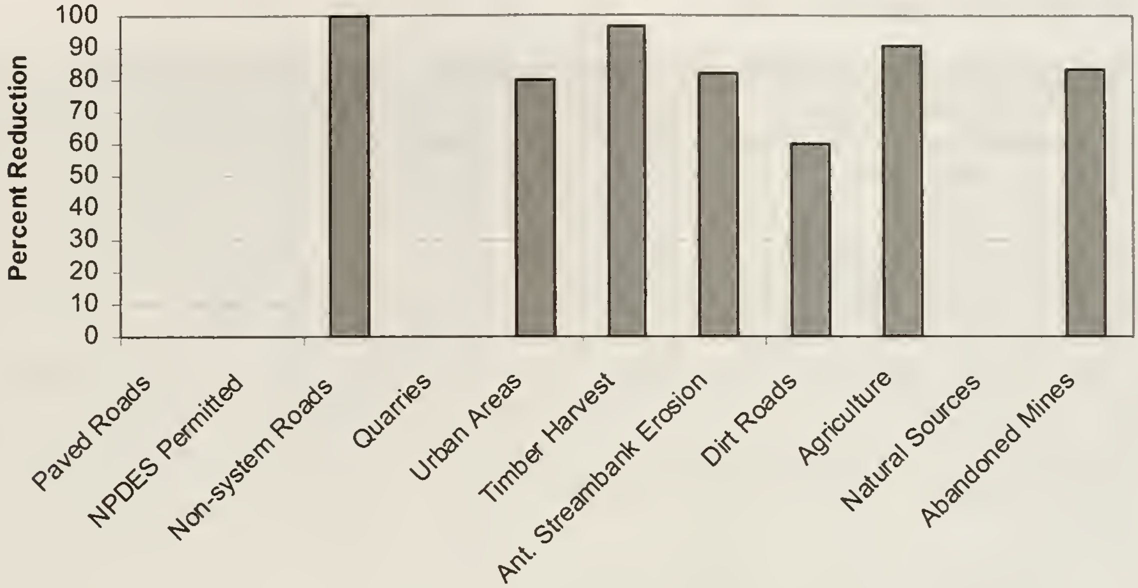

Figure 3-19. Percent reductions in zinc loading by source category.

3.4 WATER TEMPERATURE

The Problem:	Available data suggest that existing temperatures in Prickly Pear Creek are higher than natural stream temperatures. Increased stream temperatures can have negative effects on fish and aquatic life, potentially limiting reproduction and feeding habits and causing shifts in fish species composition from coldwater to warmwater fish.
Water Bodies of Concern:	Prickly Pear Creek
The Source:	Human-caused riparian degradation, flow alterations, and point source discharges.
In-Stream Temperature Goals:	Attain and maintain the state's applicable numeric and narrative temperature water quality standards.
The Solution:	Improve riparian vegetation and increase streamflows.

Technical reports prepared in support of the metals overview presented in this section of Volume II include:

- ***Appendix A*** *– Total Maximum Daily Load Summary*
- ***Appendix G*** *– SSTEMP Temperature Modeling*
- ***Appendix H*** *– Supplemental Monitoring and Assessment Strategy*

3.4.1 Water Temperature Impairment and Water Bodies of Concern

Fish and aquatic life are adapted to live within a specific range of stream temperatures. When stream temperatures are increased, fish and aquatic life begin to show impairment, ranging from reduced reproduction to altered feeding habits (USEPA, 1976; Coutant, 1977; Cherry et al., 1977; Bell, 1986; Lee and Rinne, 1980). Prolonged periods of extremely warm temperatures can be fatal. Over several years, increased stream temperature ultimately leads to a shift from primarily coldwater species (i.e., salmonids) to warmwater fish species.

Based on the results presented in Volume I, temperature problems currently exist in the water bodies listed below and depicted in Figure 3-20.

- Prickly Pear Creek (MT411006_040) – Confluence with Lump Gulch to the Wylie Drive Bridge (10.2 miles).
- Prickly Pear Creek (MT411006_030) – Wylie Drive to Helena wastewater treatment plant discharge (4.3 miles).
- Prickly Pear Creek (MT411006_020) – Helena wastewater treatment plant discharge to the mouth (5.9 miles).

Elevated stream temperatures have been documented in these water bodies. Volume I provides details regarding the degree of impairment and how the impairments are manifested. In general, impairments are due to riparian degradation and flow alterations.

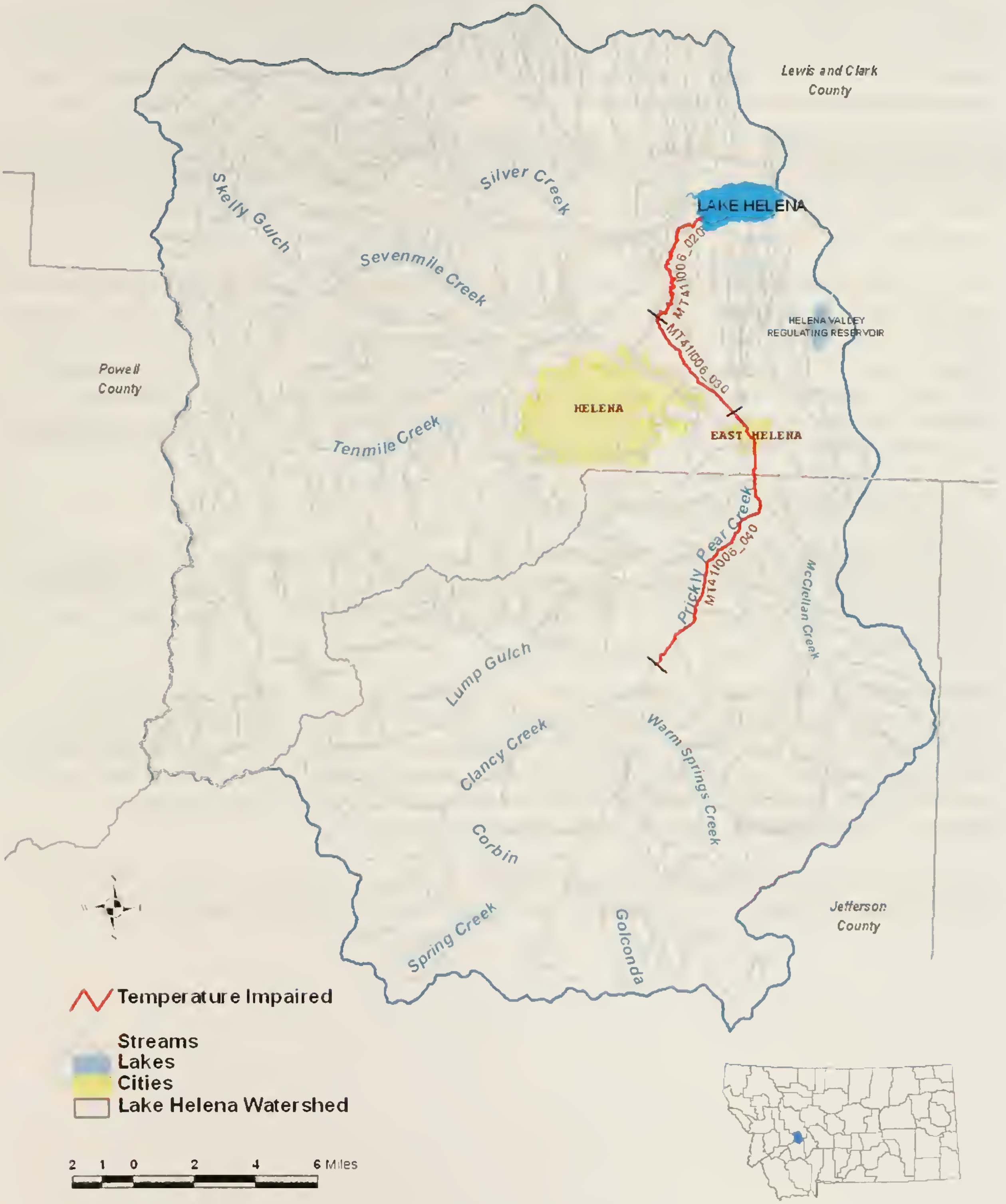

Figure 3-20. Water temperature impaired water bodies in the Lake Helena watershed.

3.4.2 Sources of Temperature Impairment in Prickly Pear Creek

Anthropogenic sources of temperature change in Prickly Pear Creek include flow alterations, riparian degradation, and point source discharges. The SSTEMP model was used to estimate the impacts from each of these sources during a critical summer, low flow event (see Appendix G for details regarding sources and the SSTEMP model). Model results indicate that in Prickly Pear Creek segment MT41I006_040, riparian degradation increases the average daily stream temperature by 0.90 degrees Fahrenheit. Flow alterations increase the stream temperature by another 1.8 degrees Fahrenheit, and point source discharges have a negligible effect. Given the model uncertainty, anthropogenic sources increase the average daily stream temperature in segment MT41I006_040 by 2.7 ± 0.5 degrees Fahrenheit.

Downstream of the Wylie Drive Bridge, Prickly Pear Creek is completely dewatered during low flow summer months (segment MT41I006_030). Therefore, the SSTEMP model could not be used. Near the Helena WWTP outfall, flow returns to Prickly Pear Creek via groundwater recharge, point sources, and irrigation returns. Given the complications associated with upstream flow alterations, it is not possible at this time to evaluate the effects of riparian degradation or dewatering on temperature in this stream segment. However, a riparian survey suggests that current conditions (i.e., degraded riparian vegetation) are most likely causing some level of temperature impairment.

3.4.3 In-Stream Temperature Goals

The ultimate goal of this plan and associated TMDLs is to attain and maintain water quality standards. Montana's water quality standards for temperature are numeric. However, the definition of "naturally occurring" water temperature within the state standard must be interpreted to derive measurable water quality goals.

Since the success of this plan and associated TMDLs will be evaluated five years after it is approved, flexibility must be provided herein for the interpretation of naturally occurring water temperature in Prickly Pear Creek. The water quality standards and indicators presented in Table 3-11 are proposed as endpoint water quality goals (or targets) for temperature, in recognition of the fact that they may need to be changed in the future as new information becomes available and/or DEQ implements a new methodology for interpreting naturally occurring water temperature.

The suite of indicators used to evaluate compliance with Montana's temperature standards in the future should be selected based on the best data, information, and methods available at that time.

Table 3-11. Proposed temperature water quality endpoints for Lake Helena watershed streams.

Water Quality Indicator	State Water Quality Standard
Water Temperature: A change in in-stream water temperature due to anthropogenic sources, or a variation from a reference condition.	**B-1 Class Waters:** ≤ 1° F when water temperature is < 67 °F ≤ 0.5° F when water temperature is > 67 °F **I Class Waters:** No increase in naturally occurring water temperature.

Water Quality Indicator	Rationale for Selection of this Indicator	Proposed Criteria
Percent Shade	Shading provided by riparian vegetation is a significant factor for reducing thermal energy input to Prickly Pear Creek. Riparian vegetation can also influence channel form and the amount of surface area exposed to solar heating.	60 percent effective shade
Fish Population Metrics	The presence of coldwater fish can be an indication of the temperature suitability of a stream, when the water body is not limited by other water quality or habitat constraints.	MFISH rating of "best" or "substantial" coldwater fishery
Streamflow	Because water has a high specific heat capacity, larger volumes of water are subject to smaller fluctuations in temperature. By increasing flow, the stream will be more resistant to temperature increases.	Maintain MFWP's recommended year-round aquatic life survival flow targets of 8 to 22 cfs for Prickly Pear Creek from the headwaters to East Helena and 14 to 30 cfs from East Helena to Lake Helena.

3.4.4 The Solution

The solution to the temperature problem in Prickly Pear Creek is to reduce the impacts from anthropogenic temperature sources. Using the temperature targets, the necessary temperature reduction in segment MT41I006_040 (Lump Gulch to Wylie Drive Bridge) is 2.2 degrees Fahrenheit. To meet this target, it is proposed that riparian vegetation should be restored to its maximum potential along the entire length of this segment. This would result in a projected 0.9 degree Fahrenheit decrease in stream temperature. It is also recommended that flows should be augmented by a minimum of 8.5 cubic feet per second. This would result in a projected 1.3 degree Fahrenheit decrease in stream temperature. It is recognized here that neither Montana DEQ nor U.S. EPA has authority to regulate streamflows or the condition of riparian vegetation. Therefore, implementation of this temperature TMDL will be voluntary, with watershed stakeholders ultimately deciding on an appropriate restoration strategy. All TMDL elements for this segment are presented in Appendix A.

At this time, temperature TMDLs could not be calculated for Prickly Pear Creek downstream of Wylie Drive. During critical summer low flow months, the stream is dry between the Wylie Drive Bridge and the Helena wastewater treatment plant outfall (segment MT41I006_030) due to flow diversions. Flows in the next downstream segment (MT41I006_020) primarily consist of groundwater recharge, irrigation returns, and tile drainage and conditions there are isolated from the upstream temperature impairments. Sources in both segments MT41I006_030 and MT41I006_020 will need to be reevaluated after implementation of the temperature TMDL for segment MT41I006_040. Any necessary TMDLs will be calculated at that time. Additionally, temperature monitoring is proposed for the Helena and East Helena WWTP outfalls to evaluate the temperature impacts from these two point sources (see Appendix H). This information will be incorporated into the TMDLs when it becomes available.

4.0 CONCEPTUAL IMPLEMENTATION STRATEGY

The lake Helena Framework Water Quality Restoration Plan and TMDLs establishes a starting point for addressing a host of water quality problems and pollution sources throughout a very large geographic area. The plan identifies the desired water quality endpoints, and quantifies the amount of pollutant reductions, by source, that will be required to restore water quality and beneficial water uses. It also defines, in general terms, a diverse assortment of restoration actions and management approaches. We acknowledge that implementing this plan, and achieving the desired water quality improvements, will not be easy.

Permanent solutions to the many and varied water quality issues will only be realized through teamwork, commitment, and ongoing planning by public entities and private citizens. The proposed phased nature of the plan, and the remaining data gaps and uncertainty, will require a mechanism for continued oversight and coordination, and a monitoring program and feedback loop. Ultimately, the success of the Lake Helena watershed water quality restoration plan will be determined by the local community and their level of support and commitment towards continuing the implementation process over the coming decades.

We acknowledge that the real work lies ahead, and that it won't happen spontaneously. Some proposed action items for ensuring the success of the Lake Helena watershed plan are described in the following paragraphs.

4.1 PUBLIC EDUCATION AND OUTREACH

The State of Montana has a variety of groups involved in watershed restoration work. It has been clearly experienced and documented that implementation of water quality restoration activities take an extensive amount of time in terms of educating the public on the local problems and to develop stakeholder buy-in to the various restoration activities that need to occur. The need for public education and outreach is the same for the Lake Helena Planning Area. Until a higher level of public understanding and support is achieved, it will be difficult to successfully implement this plan.

In order to facilitate transition from the planning steps taken by the state and federal agencies in Phase II of the Lake Helena process to development of a locally driven implementation effort, U.S. EPA and MDEQ propose to schedule and conduct a series of stakeholder meetings as a starting point. The purpose of the meetings would be to review the technical basis for the plan in layman's terms, and to elicit cooperation and build support for pursuing the next steps. Targeted audiences would be local watershed groups, relevant local, state, and federal agencies, conservation districts, municipalities, landowners, and the general public. An effort will also be made to identify potential stakeholders that may have been overlooked. The public meetings may be geographically based so that residents of each sub-basin (e.g., Prickly Pear Creek watershed) can have focused discussions on their primary areas of interest. The timeframe for conducting these meetings is proposed to run from January through May 2006.

At the conclusion of these meetings, U.S. EPA and MDEQ envision a strengthening of efforts that have been conducted to date and the establishment of a key set of stakeholders willing to work to implement voluntary point source and non-point source activities. MDEQ's Watershed Restoration Implementation Section would be available to provide continued assistance to the local participants in pursuing these activities.

4.2 COORDINATED WATERSHED-SCALE APPROACH

EPA and MDEQ feel strongly that a comprehensive watershed based approach is needed to successfully implement the Lake Helena watershed plan. The basic premise for a watershed approach is that many water quality problems are best solved at the watershed level rather than at the individual water body or point source discharger level. This is particularly true in the Lake Helena watershed where more localized water quality impairments in the Prickly Pear, Tenmile, and Silver Creek sub-basins also contribute to downstream problems in Lake Helena, and quite likely Hauser Reservoir and the Missouri River. By simultaneously addressing all pollution sources and potential future sources on a watershed-wide basis, we can set the stage for comprehensive, equitable and lasting solutions.

This plan addresses a variety of water quality issues associated with the following four categories of pollutants: nutrients, metals, sediment, and temperature. While each of these categories have been addressed separately in the main body of this document, and each water body/pollutant combination is addressed separately in the TMDLs presented in Appendix A, it is recognized that there is a great deal of commonality in the solutions that may be applied to restore water quality. For example, lack of riparian vegetation reduces the amount of shade and thereby increases stream temperatures. The solution for reducing stream temperatures is to restore the riparian vegetation community. Since healthy riparian vegetation communities also buffer streambanks against erosion and filter sediments, this solution addresses metals, sediment, and nutrient problems as well as temperature problems. As another example, since metals and some forms of nutrients are often adsorbed onto sediment, almost all of the recommended measures to reduce sediment loading will also reduce metals and nutrient loading.

Within a comprehensive watershed framework, we remain open to using the major sub-basins as a focal point for implementation of various restoration activities. For example, the Upper and Lower Tenmile Watershed Groups, and the newly formed Prickly Pear Watershed Group, may be in the best position to direct implementation activities within those respective sub-basins. These activities could include weed control, oversight of abandoned mine cleanup activities, streambank stabilization and erosion control measures, application of agricultural best management practices, landowner education efforts, and others. However, we feel that some sort of mechanism will be required to coordinate all of the various activities on a watershed scale, even though many may be pursued on a localized level. A conceptual framework is discussed in the next section.

4.3 INSTITUTIONAL FRAMEWORK

There are 11 unique sources that will need to be addressed, and 24 watershed stakeholder groups/entities that will likely need to participate to effectively implement this plan.

The Lake Helena watershed water quality restoration plan includes recommendations for numerous point and non-point source pollution control measures involving many different entities. An effective organizational framework is needed to facilitate planning, funding, implementation, and coordination of individual restoration measures as well as the watershed-wide plan as a whole.

Since neither Section 303(d) of the Clean Water Act nor the Montana Water Quality Act creates any implementing authority for TMDLs, implementation will rely on a combination of regulatory and non-regulatory means that will ideally be lead by watershed stakeholders. The obvious starting point for the development of an institutional framework to implement this plan would be those stakeholders who have authority over, or association with, the most significant current and future pollutant sources. Table 4-1 provides a list of the top five most important sources for each of the pollutants considered in this analysis along with the watershed stakeholders. All told, there are 11 unique sources that will need to be addressed, and 24 watershed stakeholder groups/entities that will likely need to participate to effectively implement this plan. The 11 unique sources include: municipal wastewater treatment facilities, septic systems, the Helena Valley Irrigation District, agriculture, urban areas, unpaved roads, timber harvest, streambank erosion, abandoned mines, degraded riparian vegetation (i.e., lack of shade), and dewatering. The associated watershed stakeholders that will need to part of the solution are listed below, in no particular order of importance.

Watershed Stakeholders

MT. Department of Environmental Quality
- Water Quality Protection Program
- TMDL Program
- Subdivision Review Program
- Permitting Program

U.S. Environmental Protection Agency
- Superfund Program
- TMDL Program
- Non-point Source Program

City of Helena
City of East Helena

Helena Valley Irrigation District
U.S. Bureau of Reclamation
U.S. Bureau of Land Management
Jefferson County
- Board
- Commission
- Public Works/Roads
- Conservation District

Helena National Forest
MT Dept. of Natural Resources and Conservation
Private Landowners

Lewis & Clark County
- Board
- Commission
- Public Works/Roads
- Water Quality Protection District
- Lower Tenmile Watershed Group
- Prickly Pear Watershed Group
- City/County Health Department
- Community Development and Planning

Natural Resource Conservation Service
- Lewis and Clark County Conservation District

Montana Department of Transportation
ASARCO
Ash Grove Cement
Helena Sand and Gravel
Montana Tunnels
Montana Rail Link

MDEQ has responsibility for overseeing the implementation of TMDLs on a statewide basis. At the same time, MDEQ does not have the regulatory or statutory authority or funding mechanisms to implement the many and varied solutions to address each of the primary sources of water quality degradation in the watershed. This will have to be conducted at the local level. It is proposed that MDEQ and EPA work with the watershed stakeholders to establish a Lake Helena Watershed Committee that would oversee and coordinate the implementation of the Lake Helena water quality restoration plan. Representation on the committee would include all watershed stakeholders, including local watershed groups, municipal and county governments, conservation districts, state natural resource agencies, the federal land management agencies, local conservation organizations, various businesses and industry, and citizens at large. Individual work groups would need to be established within the committee to focus on a series of sub-tasks of the restoration plan, for example public education, point source controls, non-point source controls, monitoring and data gaps, flow enhancement, and others. Another tier of the organizational structure could provide implementation oversight for activities that may occur within each of the three major sub-basins. A separate work group could focus on securing and coordinating overall project funding.

The committee would create a work plan and budget, and secure commitments from participants for various implementation measures. These could take the form of activities already being pursued by the separate entities represented within the Lake Helena Watershed Committee. Some examples are septic system maintenance education by Lewis and Clark County, erosion control projects by the local watershed groups, forest travel management planning by the Helena National Forest, planned infrastructure improvements by the City of Helena, and others. Other needed measures can be planned well in advance, with implementation and funding details worked out by the committee.
Incentives for participation in the Lake Helena Watershed Committee would come in part from funding opportunities that are available for TMDL implementation activities, for example the annual EPA Section 319 grants. Another incentive would come from grant leveraging opportunities where one funding source could be used as a matching contribution towards another grant. A third incentive relates to equitability issues, where the work and responsibility of attaining the necessary pollutant reductions is shared by multiple parties. Perhaps the greatest benefit to participants will be the actual water quality improvements that can only be realized through teamwork and a unified approach to watershed-wide water quality improvement.

Collectively, a broad base of stakeholders operating within this type of framework could optimize implementation efforts by pooling resources and expertise, and by improving communication and coordination among all parties.

Table 4-1. Top five pollution sources in the Lake Helena watershed and corresponding watershed stakeholders.

Nutrients		Sediment		Metals		Temperature	
Sources	**Stakeholders**	**Sources**	**Stakeholders**	**Sources**	**Stakeholders**	**Sources**	**Stakeholders**
Municipal Wastewater Treatment Facilities	City of Helena, City of East Helena, MDEQ Wastewater Permitting Program, MDEQ State Revolving Fund Program	Unpaved Roads	Helena National Forest, Lewis and Clark and Jefferson County Governments, MDEQ Subdivision Review Program, Private Landowners	Abandoned Mines	EPA Superfund Program, MDEQ Abandoned Mine Program	Degraded Riparian Vegetation (i.e., lack of shade)	Private Landowners, Conservation Districts, LCWQPD
Septic Systems	MDEQ Subdivision Review Program, Lewis & Clark and Jefferson County Boards and Commissions, City of Helena, City of East Helena, LCWQPD, Private Landowners	Agriculture	Conservation Districts, NRCS, Helena Valley Irrigation District, Bureau of Reclamation, Private Landowners	Agriculture	Conservation Districts, Natural Resource Conservation Service, Helena Valley Irrigation District, Bureau of Reclamation, Private Landowners	Dewatering	Helena Valley Irrigation District, Bureau of Reclamation, Conservation Districts, NRCS, EPA Superfund Program, City of Helena, Private Landowners
Helena Valley Irrigation District	Helena Valley Irrigation District, Bureau of Reclamation, Conservation Districts, NRCS, EPA Superfund Program, City of Helena, Private Landowners	Timber Harvest	Helena National Forest, Department of Natural Resources and Conservation, Bureau of Land Management, Private Landowners	Unpaved Roads	Helena National Forest, Lewis and Clark and Jefferson County Governments, MDEQ Subdivision Section, Private Landowners	NA	
Agriculture	Conservation Districts, Natural Resource Conservation Service, Helena Valley Irrigation District, Bureau of Reclamation, Private Landowners	Streambank Erosion	Private Landowners, Conservation Districts, LCWQPD	Streambank Erosion	Private Landowners, Conservation Districts, LCWQPD	NA	
Urban Areas	MDEQ Stormwater Permitting Program, MDEQ Subdivision Review Program, Lewis & Clark and Jefferson County Boards and Commissions, City of Helena, City of East Helena, LCWQPD, Private Landowners	Abandoned Mines	EPA Superfund Program, MDEQ Abandoned Mine Program, Lewis and Clark Water Quality Protection District	Timber Harvest	Helena National Forest, Department of Natural Resources and Conservation, Bureau of Land Management, Private Landowners	NA	

4.4 ADAPTIVE MANAGEMENT

Conclusions and recommendations contained in the Lake Helena restoration plan are based on the best information and data that are currently available. Nonetheless, we acknowledge that uncertainties or data gaps exist with regard to some of the proposed water quality targets, TMDLs, and pollutant allocations, especially for Lake Helena. Other unknowns are present as well, such as the ability of the proposed restoration measures to completely attain the needed pollutant reductions. The proposed adaptive management approach will allow us to move forward with water quality improvement activities at the same time that additional data gathering occurs. These data will then be used to confirm or adjust some of the plan's technical assumptions, to fill remaining data limitations (e.g., Lake Helena), and to evaluate the effectiveness of restoration measures on an individual and collective basis.

4.5 MEASURING SUCCESS

Focused monitoring efforts will be required to fulfill three primary objectives:

- Obtain additional data to address information gaps and uncertainty in the current analysis (data gaps monitoring and assessment).
- Ensure that identified management actions are undertaken (implementation monitoring)
- Ensure that management actions are having the desired effect (effectiveness monitoring)

Proposed basic elements of a monitoring strategy to meet these three objectives are described below, with expanded discussions provided in Appendix H of this report. During the implementation phase, a more detailed monitoring and analysis plan will need to be prepared.

4.5.1 Data Gaps Monitoring

Monitoring to fill current data gaps is the highest priority because these data are needed to move forward with specific restoration strategies. For example, only interim nutrient targets have been established for the streams in the Lake Helena watershed due to uncertainty associated with the technical or economic feasibility of attaining the proposed values. Similarly, no nutrient concentration targets are presented for Lake Helena due to limited historic and recent water quality data and an incomplete understanding of the hydrologic relationship between Lake Helena and Hauser Reservoir. A lack of data also resulted in an incomplete understanding of several of the metals impairments. Additional monitoring is therefore needed to address these data gaps and will consist of the following:

- Watershed hydrology and groundwater/surface water studies to better understand water management, groundwater, and water quality interactions within the Helena Valley.
- An in-stream nutrient target setting and source assessment study to develop a better understanding of the relationship between nutrient concentrations and beneficial use impairment in lower Prickly Pear Creek, including the compilation of sufficient data for a more refined modeling analysis.
- A study of Lake Helena and Hauser Reservoir nutrient dynamics to better assess conditions within these two water bodies, and to refine the nutrient loading/lake response model.
- Metals monitoring in segments that had limited data to ascertain the level of impairment with confidence.
- Temperature monitoring to better understand the impact from point source discharges and flow alterations.
- A study to collect additional data for model calibration and refinement.

EPA and MDEQ propose to take the lead in performing these activities assuming adequate budgets and resources. Additional details are provided in Appendix H of this report.

4.5.2 Implementation Monitoring

The purpose of implementation monitoring is to document whether or not management practices were applied as designed. Objectives of an implementation monitoring program include:

- Measuring, documenting, and reporting the watershed-wide extent of BMP implementation and other restoration measures, including point source controls.
- Evaluating the general effectiveness of BMPs as applied operationally in the field.
- Determining the need and direction of BMP education and outreach programs.

Implementation monitoring consists of detailed visual monitoring of BMPs, with emphasis placed on determining if they were implemented or installed in accordance with approved design criteria. This type of information will provide the Lake Helena Watershed Committee with an inventory of where BMPs have been applied and their effectiveness. The various watershed stakeholders should take the lead in performing the implementation monitoring as it is likely to vary by each type of BMP. For example, the USFS has the most expertise in assessing forestry BMPs whereas City of Helena personnel are likely most familiar with urban stormwater controls.

4.5.3 Effectiveness Monitoring

Montana Code Annotated 75-5-703(9)(c) provides a provision requiring that MDEQ evaluate all TMDLs five years after they have been completed and approved. A formal review of the Lake Helena TMDL will therefore occur in 2011/2012 and will use the water quality endpoints identified for each pollutant (and/or the endpoints that best represent interpretations of the water quality standards in affect at that time) to assess overall progress toward meeting water quality restoration goals. This effort will include a combination of water quality and biological monitoring and habitat assessment aimed at determining the effectiveness of restoration activities. Although this assessment can be made based on data collected by MDEQ only in year five, a much more thorough assessment will be possible if additional data are collected during the intervening years. Due to MDEQ resource constraints, these additional data would need to be collected by watershed stakeholders.

Nutrient effectiveness monitoring in Prickly Pear Creek should consist of monthly sampling of general water quality in 2011, as well as targeted collection of attached algae and dissolved oxygen data during the critical summer months. One purpose of this monitoring is to assess the degree to which the implemented point and non-point source controls have reduced ambient nutrient concentrations compared to the available historical data. Another purpose is to determine whether in-stream nutrient reductions have lead to corresponding decreases in algal standing crops and the magnitude of dissolved oxygen sags. Nutrient effectiveness monitoring should also be conducted in Lake Helena and Hauser Reservoir in 2011 using the nutrient/limnologic parameters that were previously described in Section 2.3 above.

Sediment water quality endpoints should be assessed on a maximum interval of five years in order to judge the degree of target acquisition. However, biannual data collection at fixed plots is more applicable, and should be conducted following the implementation of restoration activities, with subsequent data collection on every fifth year. Three years of data collection every five years will provide a basis for trend analysis, and determination of the level of benefits associated with restoration activities. The exception to the biannual data collection strategy is suspended sediment sampling, which should occur on a more frequent basis (quarterly, if resources can support this level of intensity).

Temperature monitoring of Prickly Pear Creek segments should be conducted seasonally for a minimum of three years following the implementation of control measures. Montana DEQ protocols should be used for all sampling events, and the data should be recorded and submitted to the MDEQ. The effectiveness monitoring strategy for temperature should include in-stream temperature and streamflow monitoring and the collection of weather data to determine representativeness of the results. Records from the nearest NOAA weather station should be used to monitor local weather for the area of interest.

Effectiveness monitoring for metals should consist of sampling the metals of concern, along with hardness, pH, and instantaneous flow. Monthly sampling in 2011 is recommended at the mouth of every listed segment throughout the Lake Helena watershed. Additional sampling during runoff events (from snowmelt and summer storms) is also recommended. The data will be evaluated for the presence and spatial persistence of any numeric criteria violations.

4.5.4 Future Sources

Future Sources

Although it may be possible to attain water quality standards by addressing sources that exist today, it will not be possible to maintain water quality standards unless decisions about potential future sources are made in consideration of water quality.

Much of this document, and associated TMDLs in Appendix A, focuses on addressing current pollutant sources in an effort to attain water quality standards. It will be equally important to address future pollutant sources in order to maintain the water quality improvements. For example, in Section 3.2.1 it was noted that TN and TP loads are predicted to increase by 43 and 78 percent, respectively, in the foreseeable future if population growth continues at current rates. Nutrient loading is unequivocally linked to population growth and the two cannot be separated. According to EPA's *Onsite Wastewater Treatment Systems Manual* (USEPA, 2002), one person generates 4.8 to 13.7 pounds of nitrogen and 0.8 to 1.6 pounds of phosphorus per year. Municipal wastewater plants and individual septic systems are currently among the top three most important sources of TN and TP in the Lake Helena watershed. Since municipal wastewater treatment or septic systems are the conventional means for controlling the discharge of these pollutants from domestic wastewater sources, these two sources will become even more important nutrient sources in the future as the population increases. Increasing the human population within the watershed will produce an incremental increase in nutrient loading. Septic systems do not effectively control TN loading, and there are technical and economic constraints associated with attaining the maximum level of treatment for both TN and TP in municipal wastewater treatment facilities. Therefore, it seems inevitable that nutrient loading to the waters in the Lake Helena watershed will increase in the future as the population grows. It is imperative that future decisions regarding land use changes be made with full knowledge and understanding of the related water quality implications. It is also essential that cumulative affects are considered and all proposed actions are evaluated at the watershed scale.

Although the example provided above focuses on future nutrient sources, the same concept holds true for the other pollutants considered in this analysis. Future timber harvest, future unpaved roads, new mining facilities, etc. can all be expected to contribute to increased pollutant loading.

A number of tools have been prepared to support the technical analyses presented in this document, and these will be fine tuned in the future as part of the planned Lake Helena Phase III efforts (see Section 3.2.3.2 and Appendix H). These tools can and should be used to evaluate the water quality implications of future land use decisions in the Lake Helena watershed. As part of Phase III, the watershed scale nutrient loading model developed in Phase II will be tailored for use specifically in the Prickly Pear sub-watershed. One example application of this modeling tool would to evaluate the net water quality benefits that could be provided by extending the sewer services in the Helena Valley to previously unsewered areas.

5.0 SUMMARY OF PUBLIC INVOLVEMENT ACTIVITIES

5.1 INTRODUCTION

EPA and Montana DEQ recognize the critical importance of public and stakeholder involvement in the Lake Helena water quality restoration planning process. The agencies are sensitive to the fact that the basin's water quality problems stem from many diffuse pollution sources whose resolution will require cooperative, largely voluntary approaches. We understand that landowners, agricultural producers, private business owners, the federal land management agencies, and other government and municipal entities cannot be expected to actively participate in the water quality restoration process if they are not kept informed as the plan is developed, and if their input is not solicited and valued. In recognition of these needs, staff of the Montana EPA office and Montana DEQ, together with Lake Helena project contractors and local watershed group coordinators, have made a concerted effort to provide opportunities for public dialogue and input throughout the Lake Helena water quality restoration planning process.

The following is a summary of activities conducted between 2003 and May 2006 to keep local watershed residents and agency representatives informed of progress in developing Volumes I and II of the Lake Helena plan, to provide opportunities for input and dialogue, and to address coordination issues.

5.2 LOCAL WATERSHED GROUP MEETINGS AND WORKSHOPS

Project staff attended regular meetings of the Upper Tenmile Watershed Group, the Lower Tenmile Watershed Group and, more recently, the Prickly Pear Watershed Group to provide updates on the Lake Helena project, to answer questions and participate in discussions, and to keep appraised of activities with potential relevance to the Lake Helena project.

Staff attended Lower Tenmile Watershed Group meetings on January 15, February 11, March 18, May 20, July 15, October 16, and November 20, 2003; on February 19, March 25, and April 15, 2004; on February 17, April 21, and September 15, 2005; and on February 16, 2006. Focused presentations on the Lake Helena project were given at the meetings on January 15, 2003, February 17, 2005, and February 16 and May 4, 2006. A lapse in attendance of the meetings in mid-2004 was due to a temporary slow down in the project and a lack of reportable items. Lake Helena project staff participated in volunteer riparian planting activities along Tenmile Creek in May 2003, 2004, 2005, and 2006.

Upper Tenmile Watershed Group meetings were attended on February 27, March 27, May 29, July 31, and September 25, 2003; and on February 26 and March 25, 2004. A focused presentation on the Lake Helena project was given at the meeting on February 27, 2003.

A Prickly Pear Watershed Group meeting was attended on May 3, 2005. A presentation on water quality issues in the Prickly Pear watershed was given at a Prickly Pear Know Your Watershed Workshop on April 24, 2004. This workshop set the stage for creation of the Prickly Pear Watershed Group.

5.3 CONSERVATION DISTRICT MEETINGS

Lake Helena project staff attended meetings of the Lewis and Clark County Conservation District on March 13, June 19 and August 14, 2003; on January 8 and October 14, 2004, and on January 19 and March 10, 2005; and meetings of the Jefferson Valley Conservation District on February 18, April 15, July 15, October 21, and November 18, 2003 to provide updates on the Lake Helena project and to answer questions.

5.4 AGENCY PARTNERSHIPS AND CONSULTATION

Several state and federal agencies have been closely involved as cooperators in the Lake Helena water quality restoration project. Staff of the Helena National Forest Supervisor's Office assisted extensively with field monitoring and assessment activities in summer 2003, and have continued to be closely involved with design of pollution source assessment approaches and water quality target setting. Montana Fish, Wildlife and Parks staff assisted with the project through the provision of data, and by collecting fish tissue from area streams for mercury analysis. A host of local, state and federal agencies were contacted in early 2003 as part of an extensive data gathering effort and graciously provided access to their reference libraries and data pertaining to water quality and land management activities in the Lake Helena watershed. The Lewis and Clark County Water Quality Protection District staff person who serves as coordinator for the Lower Tenmile and Prickly Pear Watershed Groups has assisted the Lake Helena project team in the gathering of data, disseminating information to the public, and arranging meetings.

The Montana Department of Transportation convened an inter-agency and public group in 2003 to address coordination issues associated with plans to pave the Marysville Road. Lake Helena project staff participated in meetings of this group on a number of occasions because of potential relevance to the Silver Creek TMDLs and restoration planning process. Meetings of the Marysville Road Users' Group were attended in February, March, April, August, and October 2003; and in February 2004. A focused presentation on the Lake Helena project was given at a public hearing on the Marysville Road reconstruction plan at the Trinity School (Canyon Creek) on March 27, 2003.

Lake Helena project staff attended scoping meetings hosted by the Bureau of Reclamation on March 17, 2004 regarding renewal of water leases for the Helena Valley Irrigation District and City of Helena from the Canyon Ferry/Helena Valley Regulating Reservoir distribution system. Lake Helena project staff followed up the meeting by submitting written comments pertaining to the Lake Helena water quality restoration plan and relationships to the leasing proposal.

EPA project staff attended a meeting of the Lewis and Clark County Water Quality Protection District board of directors on February 22, 2005 to make a presentation on the Lake Helena project, to answer questions, and to discuss local coordination issues. These discussions were continued at additional meetings Helena city and county staff in April and October 2005.

Project staff worked closely with Helena National Forest staff on sediment source assessment activities and allocations. Additional meetings were held with Lewis and Clark County Water Quality Protection District and planning staff, the City of Helena Public Works Department, and East Helena municipal government regarding municipal wastewater, urban development and population growth, and conceptual TMDL implementation strategies..

Additional meetings focusing on metals TMDL coordination issues were held with the Bureau of Land Management, MDEQ Abandoned Mine Cleanup Bureau, and the EPA Superfund Program and their contractors.

5.5 LAKE HELENA TECHNICAL ADVISORY COMMITTEE

The Lake Helena project team organized and convened a meeting of a technical advisory committee on May 15, 2003 to create a sounding board for technical aspects of the Lake Helena project. The first meeting focused on data gaps, development of a monitoring plan, and selection of candidate least-impaired reference streams for use in impairment decisions. A second meeting of the group was held on

March 9, 2005 with a purpose of reviewing progress to date and discussing the rationale behind the preliminary water quality restoration targets for sediment, nutrients, metals, temperature, and salinity. The committee met for a third time on September 13, 2005 to review the results of the completed pollution source assessment work, and to discuss the TMDL allocation process. The technical committee membership includes 16 representatives including all relevant local, state and federal agencies, as well as the Lower Tenmile and Upper Tenmile watershed Group facilitators.

5.6 LAKE HELENA POLICY ADVISORY COMMITTEE

The Lake Helena project team organized and convened a meeting of a policy advisory committee on March 10, 2004 to begin a dialogue pertaining to policy planning and implementation aspects of the Lake Helena project. Project staff briefed meeting participants on the progress to date, including development of the preliminary water quality impairment status review, results of a preliminary pollution source assessment, a schedule of future activities, and anticipated population growth related challenges. A second meeting was convened on September 15, 2005 with a purpose of discussing allocation strategies and timeframes. The policy advisory committee membership includes approximately 75 individuals representing all relevant local, state and federal agencies, municipal and county government, private businesses and industry, the local watershed groups, and interested citizens.

5.7 PUBLIC INFORMATIONAL MEETINGS

A general public informational and public comment meeting on the Lake Helena Volume I document was conducted at the Montana Association of Counties office building in Helena on March 15, 2005. Notice of the meeting location and time were published in the Helena Independent Record on February 13, 2005, on the Montana DEQ website, and in individual letters distributed to Lake Helena Technical and Policy Advisory Committee members.

Two public informational meetings were held on the Lake Helena Volume II draft TMDL document in Helena during the afternoon and evening of January 12, 2006. Notice of the meeting location and times were published in the Helena Independent Record, on the Montana DEQ website, and in individual letters distributed to Lake Helena Technical and Policy Advisory Committee members.

5.8 ONE-ON-ONE CONTACTS

Lake Helena project staff have made numerous individual contacts since the project inception to gather information and advice, to inform, and to elicit cooperation. Many of these contacts and their purpose are summarized in Appendix I.

5.9 PUBLIC NOTICES

A public notice on the availability of the draft Volume I report and a notice of a public informational meeting on the project was published in the Helena Independent Record and on the MDEQ agency website on February 13, 2005.

A public notice on the availability of the draft Volume II document and notice of two public informational meetings on the project was published in the Helena Independent Record and on the MDEQ agency website in December 25, 2005. The notices also advertised the formal public comment period on the draft Lake Helena Watershed Water Quality Restoration Plan and TMDLs, which was opened on December 27, 2005 and extended to February 28, 2006.

5.10 DIRECT MAILINGS

An electronic copy of the Volume I report was mailed to nearly 100 individuals included on the Lake Helena Policy and Technical Advisory Committee mailing lists, together with a cover letter providing invitations to the March 9, 2005 Technical Advisory Committee meeting and/or the March 15, 2005 public informational meeting. An electronic copy of the draft Volume I document was also distributed to this same group via direct mail.

An electronic copy of the draft Volume II TMDL report was mailed to the individuals on the Lake Helena Policy and Technical Advisory Committee mailing lists, together with a cover letter extending an invitations to the January 12, 2006 public informational meeting.

5.11 LIBRARY POSTINGS

Bound copies of Volume I were placed in the Lewis and Clark County Library and the Montana State Library in February 2005. Availability of the document in the libraries was noticed on the MDEQ website and in the February 13, 2005 Independent Record newspaper public notice.

Bound copies of the Volume II draft document were also placed in the Lewis and Clark County Library and the Montana State Library in December 2005. Availability of the document in the libraries was noticed on the MDEQ website and in a December 2005 Independent Record newspaper public notice.

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Appendix A

Total Maximum Daily Load (TMDL) Summary

Framework Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area:

Volume II – Final Report

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1.0 INTRODUCTION

The TMDL and water quality restoration planning process in Montana involves several steps. The first step consists of characterizing the environment in which the water bodies exist (this step is referred to as "watershed characterization"). This is followed by developing a thorough understanding of the water quality problem (what pollutant is causing the impairment and how is the impairment manifested in the water body – referred to in this report as "water quality impairment status") and establishing water quality goals ("targets"). Once the water quality problem has been defined, the next step is to identify all significant sources of pollutants ("source assessment"). Then, the maximum load of a pollutant (for example, sediment, nutrients, or metals) that a water body is able to assimilate and still fully support its designated uses is determined (the total maximum daily load or TMDL). Next, the pollutant load is allocated among all sources within the watershed, including natural sources (i.e., "allocation"), and voluntary (for nonpoint sources) and regulatory control (for point sources) measures are identified for attaining the source allocations (i.e., "restoration strategy"). Last, a monitoring plan and associated corrective feedback loop are established to ensure that the control measures are effective at restoring water quality and all designated beneficial water uses.

The actual Total Maximum Daily Load is typically expressed as follows:

$$\text{TMDL} = \text{LA} + \text{WLA} + \text{MOS}$$

Where

LA = the load allocation, or the allocation to non-point sources
WLA = the waste load allocation, or the allocation to point sources
MOS = the margin of safety

Appendix A presents the TMDLs and associated allocations and margins of safety for all of the impaired waters in the Lake Helena TMDL Planning Area (Table 1-1). The water body/pollutant combinations addressed in Appendix A are listed in Table 1-2. A summary is presented in Section 15.

Table 1-1. 303(d) Listed Streams

Clancy Creek	Corbin Creek	Golconda Creek
Granite Creek (Austin Creek)	Granite Creek (Sevenmile Creek)	Jackson Creek
Jennie's Fork	Lake Helena	Lump Gulch
Middle Fork Warm Springs Creek	North Fork Warm Springs Creek	Prickly Pear Creek
Sevenmile Creek	Silver Creek	Skelly Gulch
Spring Creek	Tenmile Creek	Warm Springs Creek

Table 1-2. Water quality status of suspected impaired water bodies and required TMDLs in the Lake Helena watershed.

Water Body Name and Number	Impairment Causes[a]	Impairment Status[b]	Action
Clancy Creek, MT41I006_120	Siltation/Suspended Solids	Impaired	A TMDL is presented in Section 2.0
	Nutrients	Not impaired	No TMDL required.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 2.0.
Corbin Creek, MT41I006_090	Suspended Solids	Impaired	A TMDL is presented in Section 3.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 3.0.
	Temperature	Unknown	A TMDL will not be written at this time.
	Salinity/TDS/Chloride	Impaired for salinity and TDS. Not impaired for Chloride.	A TMDL will not be written. Impairments will be addressed by the metals TMDLs (Section 3.1).
Golconda Creek, MT41I006_070	Suspended Solids/ Turbidity	Not impaired	No TMDL required.
	Metals	Impaired	TMDLs for cadmium and lead are presented in Section 4.0.
Granite Creek, MT41I006_179	No pollutants	NA	No TMDL required.
Granite Creek, MT41I006_230	Metals	Unknown (dewatered stream)	A TMDL will not be written at this time.
Jackson Creek, MT41I006_190	Sediment	Not impaired	No TMDL required.
Jennie's Fork, MT41I006_210	Siltation	Impaired	A TMDL is presented in Section 5.0.
	Metals	Impaired	A TMDL for lead is presented in Section 5.0.
Lake Helena, MT41I007_010	Suspended Solids	Unknown	A TMDL will not be written at this time.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 6.0.
	Metals	Impaired	TMDLs for arsenic and lead are presented in Section 6.0.
	Temperature	Unknown	A TMDL will not be written at this time.
Lump Gulch, MT41I006_130	Suspended Solids	Impaired	A TMDL is presented in Section 7.0.
	Metals	Impaired	TMDLs for cadmium, copper, lead, and zinc are presented in Section 7.0.
Middle Fork Warm Springs Creek, MT41I006_100	Siltation	Impaired	A TMDL is presented in Section 14.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, lead, and zinc are presented in Section 14.0.
North Fork Warm Springs Creek, MT41I006_180	Siltation	Impaired	A TMDL is presented in Section 14.0.
	Low DO, Organic Enrichment	Not impaired	No TMDL required.
	Metals	Impaired	TMDLs for arsenic, cadmium, and zinc are presented in Section 14.0.
Prickly Pear Creek, MT41I006_060	Suspended Solids	Impaired	A TMDL is presented in Section 8.0.
	Metals	Impaired	A TMDL for lead is presented in Section 8.0.
Prickly Pear Creek, MT41I006_050	Siltation/ Suspended Solids	Impaired	A TMDL is presented in Section 8.0.
	Metals	Impaired	TMDLs for cadmium, lead, and zinc are presented in Section 8.0.
Prickly Pear Creek, MT41I006_040	Siltation/ Suspended Solids	Impaired	A TMDL is presented in Section 8.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 8.0.
	Temperature[c]	Impaired	A TMDL is presented in Section 8.0.

Table 1-2. Water quality status of suspected impaired water bodies and required TMDLs in the Lake Helena watershed.

Water Body Name and Number	Impairment Causes[a]	Impairment Status[b]	Action
Prickly Pear Creek, MT41I006_030	Siltation/ Suspended Solids	Impaired	A TMDL is presented in Section 8.0.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 8.0.
	Metals	Impaired	TMDLs for arsenic and lead are presented in Section 8.0.
	Temperature	Impaired	A TMDL is presented in Section 8.0.
Prickly Pear Creek, MT41I006_020	Siltation/ Suspended Solids	Impaired	A TMDL is presented in Section 8.0.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 8.0.
	Total Ammonia	Not impaired	No TMDL required.
	Metals	Impaired	TMDLs for arsenic, cadmium, and lead are presented in Section 8.0.
	Temperature	Impaired	A TMDL is presented in Section 8.0.
Prickly Pear Creek, MT41I006_010	Metals	Not evaluated	TMDL needs will be addressed as part of the Hauser Reservoir TMDL.
Sevenmile Creek, MT41I006_160	Siltation	Impaired	A TMDL is presented in Section 9.0.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 9.0.
	Metals	Impaired	TMDLs for arsenic, copper, and lead are presented in Section 9.0.
Silver Creek, MT41I006_150	Metals	Impaired	TMDL for arsenic is presented in Section 10.0.
	Priority organics	Not impaired	No TMDL required.
Skelly Gulch, MT41I006_220	Siltation	Impaired	A TMDL is presented in Section 11.0.
	Metals	Not impaired	No TMDL required.
Spring Creek, MT41I006_080	Suspended Solids	Impaired	A TMDL is presented in Section 12.0.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 12.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 12.0.
Tenmile Creek, MT41I006_141	Siltation	Not impaired	No TMDL required.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 13.0.
Tenmile Creek, MT41I006_142	Siltation	Impaired	A TMDL is presented in Section 13.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 13.0.
Tenmile Creek, MT41I006_143	Siltation	Impaired	A TMDL is presented in Section 13.0.
	Nutrients	Impaired	TMDLs for nitrogen and phosphorus are presented in Section 13.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, copper, lead, and zinc are presented in Section 13.0.
Warm Springs Creek, MT41I006_110	Suspended Solids/ Siltation	Impaired	A TMDL is presented in Section 14.0.
	Metals	Impaired	TMDLs for arsenic, cadmium, lead, and zinc are presented in Section 14.0.

[a] 303(d) listed cause of impairment. See water body-by-water body discussions in the following sections and/or Volume I for details regarding 303(d) listing history.

[b] Impairment status is based on Volume I.

[c] Impairment causes that have not been reflected on past 303(d) lists but that were identified during this review.

2.0 CLANCY CREEK

Clancy Creek from the headwaters to the mouth (Segment MT41I006_120, 11.6 miles) was listed as impaired on the Montana 1996 303(d) list because of siltation, suspended solids, nutrients, and metals. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, aquatic life, fishery, and drinking water beneficial uses were listed as impaired because of arsenic, lead, mercury, metals, and siltation. The additional analyses and evaluations described in Volume I found that sediment (suspended solids and siltation), arsenic, cadmium, copper, lead, and zinc are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.12 of the Volume I Report). Nutrients are not impairing beneficial uses, and therefore no TMDLs will be presented. There were insufficient data to determine if mercury is impairing beneficial uses.

Conceptual restoration strategies and the required TMDL elements for sediment and metals (i.e., arsenic, cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

2.1 METALS

The available water chemistry data suggest that aquatic life and fish in Clancy Creek are impaired by arsenic, cadmium, copper, lead, and zinc. The following sections present the required TMDL elements for these pollutants.

2.1.1 Sources of Metals in the Clancy Creek Watershed

Besides anthropogenic sediment-associated metals sources, significant contributors of metals to the stream segment are the historical mining activities in the upper watershed. The source assessment showed that, among the 303(d)-listed segments in the Lake Helena TPA, placer mine tailings are the most extensive on Clancy Creek. The headwaters of the watershed fall within the Colorado mining district while the rest is within the Clancy mining district. The MBMG Abandoned and Inactive Mines database reports mineral location, placer, underground, and surface-underground mining activities in the watershed. The historical mining types include placer, lode, and mill. In the past these mines produced manganese, lead, silver, copper, zinc, and gold. Three mines in the headwaters—Gregory, Argentine, and Crawley Camp—are within the Colorado district and are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. The state's inventory shows at least 10 other mines in the headwaters area of this watershed. Modeled sources and their metals loadings to Clancy Creek are presented in Figure 2-1 through Figure 2-5. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

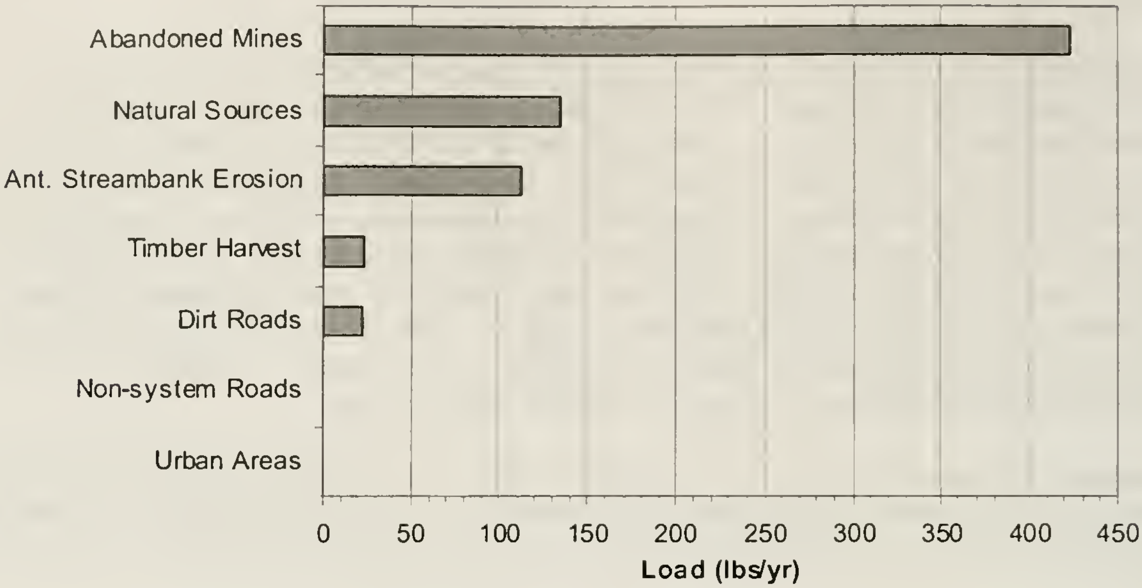

Figure 2-1. Sources of arsenic loadings to Clancy Creek.

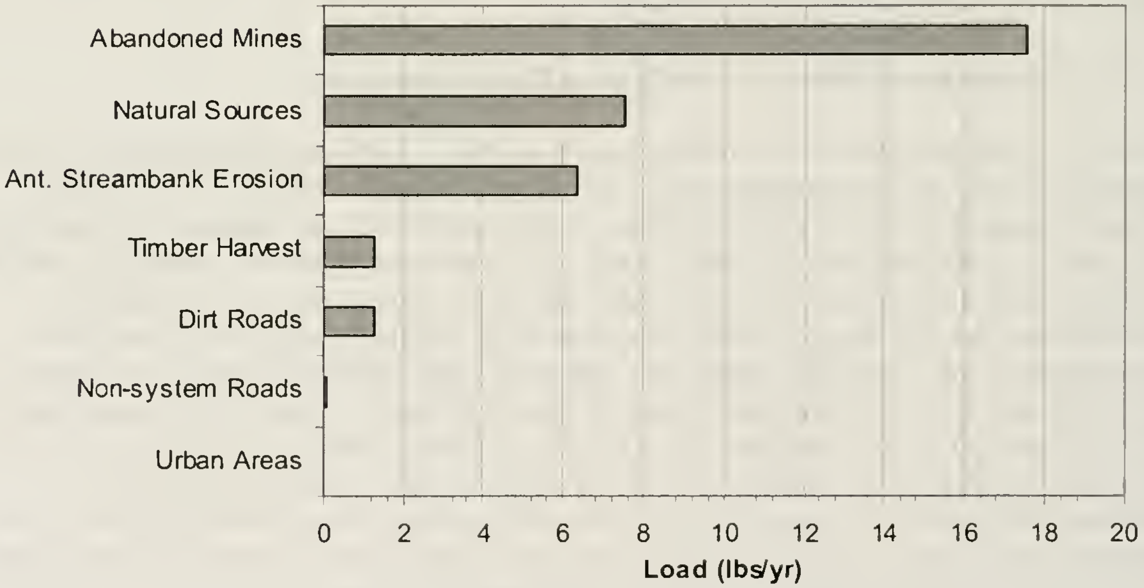

Figure 2-2. Sources of cadmium loadings to Clancy Creek.

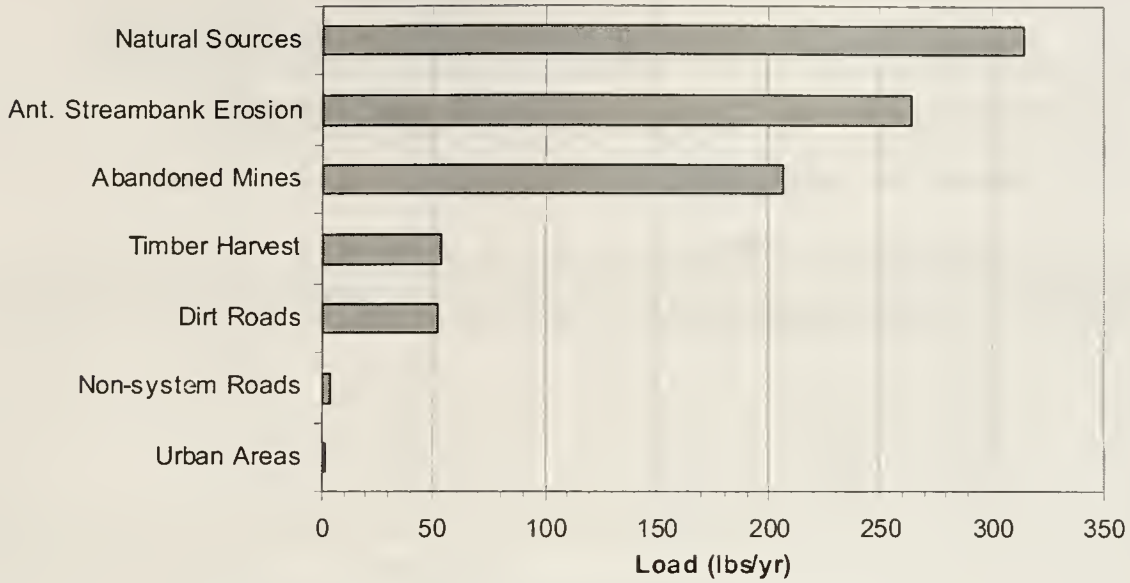

Figure 2-3. Sources of copper loadings to Clancy Creek.

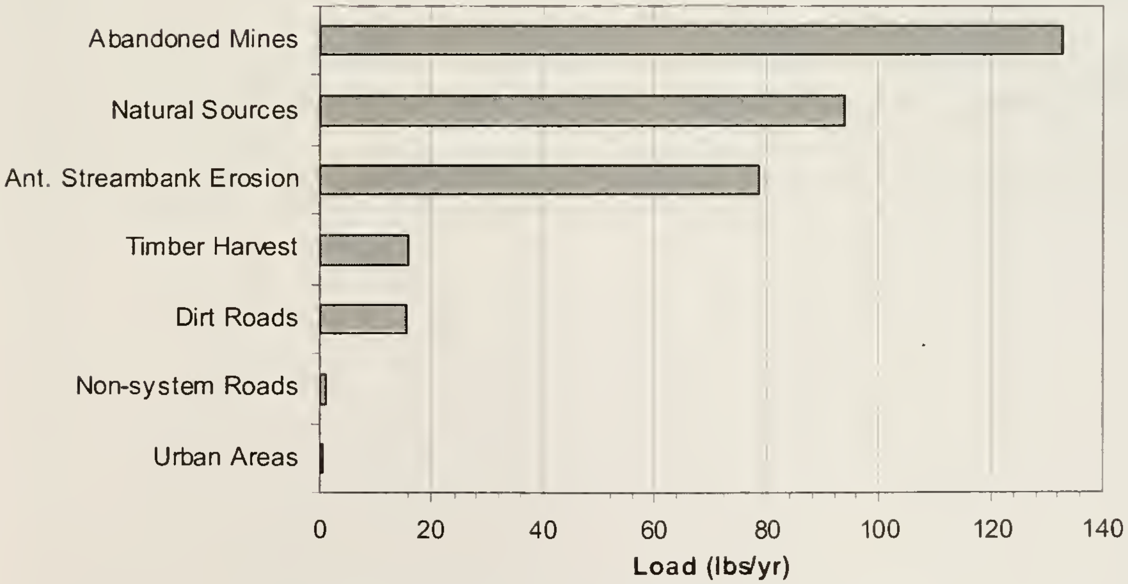

Figure 2-4. Sources of lead loadings to Clancy Creek.

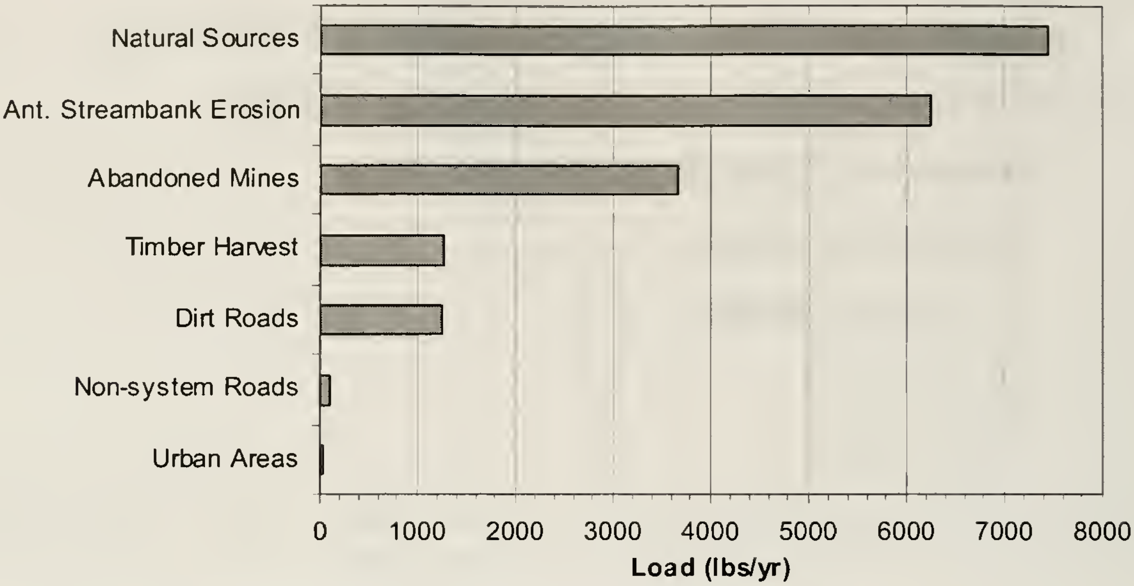

Figure 2-5. Sources of zinc loadings to Clancy Creek.

2.1.2 Water Quality Goals/Targets

The ultimate goal of this TMDL is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Clancy Creek are presented in Table 2-1.

Table 2-1. Montana numeric surface water quality standards for metals in Clancy Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10 [d]
Cadmium (TR)	2.3 at 105.6 mg/L hardness[c]	0.3 at 105.6 mg/L hardness[c]	5
Copper (TR)	14.6 at 105.6 mg/L hardness[c]	9.6 at 105.6 mg/L hardness[c]	1,300
Lead (TR)	86.3 at 105.6 mg/L hardness[c]	3.3 at 105.6 mg/L hardness[c]	15
Zinc (TR)	126.5 at 105.6 mg/L hardness[c]	126.5 at 105.6 mg/L hardness[c]	2,000

Note: TR = total recoverable.
[a] Maximum allowable concentration.
[b] No 4-day (96-hour) or longer period average concentration may exceed these values.
[c] The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).
[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

2.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 2-2 through Table 2-6. Based on the results of the source assessment (Section 2.1.1), the recommended implementation strategy to address the metals problem in Clancy Creek is to reduce metals loadings from abandoned mines, along with the implementation of the sediment TMDLs. As shown in Table 2-2 through Table 2-6, the hypothesis is that an overall, watershed scale metals load reduction of 61, 61, 42, 54, and 47 percent for arsenic, cadmium, copper, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current mining sources by 73, 77, 37, 70, and 60 percent for arsenic, cadmium, copper, lead, and zinc, respectively.

Table 2-2. TMDL, Allocations, and Margin of Safety for Clancy Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	422.9	73	114.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	112.9	81	20.9	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 81.4% (see Table 2-7), thereby reducing sediment associated metals loads from streambank erosion by 81.4%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	1.7	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	22.9	97	0.7	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	22.4	60	9.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 2-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.8	80	0.2	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 2-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	583.6	75	145.1		
	Natural Sources	134.3	0	134.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		717.9	61	279.4		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 145.1 lbs/yr + 134.3 lbs/yr + 0 = 279.4 lbs/yr** **TMDL = 0 + 0.40 lbs/day + 0.37 lbs/day + 0 = 0.77 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 2-3. TMDL, Allocations, and Margin of Safety for Clancy Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	17.5	77	4.0	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	6.3	81	1.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 81.4% (see Table 2-7), thereby reducing sediment associated metals loads from streambank erosion by 81.4%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.1	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	1.3	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1.3	60	0.5	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 2-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.0	80	0.0	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 2-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	26.5	78	5.7		
	Natural Sources	7.5	0	7.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**34.0**	**61**	**13.2**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 5.7 lbs/yr + 7.5 lbs/yr + 0 = 13.2 lbs/yr** **TMDL = 0 + 0.016 lbs/day + 0.020 lbs/day + 0 = 0.036 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 2-4. TMDL, Allocations, and Margin of Safety for Clancy Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	206.2	37	130.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	264.2	81	49.0	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 81.4% (see Table 2-7), thereby reducing sediment associated metals loads from streambank erosion by 81.4%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	4.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	53.7	97	1.6	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	52.5	60	21.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 2-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.9	80	0.4	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 2-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	582.5	65	202.8		
	Natural Sources	314.5	0	314.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of copper in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		897.0	42	517.6		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 202.8 lbs/yr + 314.5 lbs/yr + 0 = 517.6 lbs/yr** **TMDL = 0 + 0.56 lbs/day + 0.86 lbs/day + 0 = 1.42 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 2-5. TMDL, Allocations, and Margin of Safety for Clancy Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	132.9	70	40.5	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	78.8	81	14.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 81.4% (see Table 2-7), thereby reducing sediment associated metals loads from streambank erosion by 81.4%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	1.2	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	16.0	97	0.5	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	15.7	60	6.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 2-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.6	80	0.1	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 2-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	245.2	75	62.0		
	Natural Sources	93.8	0	93.8	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		339.0	54	155.8		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 62.0 lbs/yr + 93.8 lbs/yr + 0 = 155.8 lbs/yr** **TMDL = 0 + 0.17 lbs/day + 0.26 lbs/day + 0 = 0.43 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 2-6. TMDL, Allocations, and Margin of Safety for Clancy Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	3,673.2	60	1,457.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	6,259.7	81	1,161.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 81.4% (see Table 2-7), thereby reducing sediment associated metals loads from streambank erosion by 81.4%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	95.4	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	1,271.2	97	38.1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1,244.0	60	497.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 2-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	45.8	80	9.2	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 2-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	12,589.3	75	3,163.7		
	Natural Sources	7,449.6	0	7,449.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of zinc in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**20,038.9**	**47**	**10,613.3**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 3164 lbs/yr + 7450 lbs/yr + 0 = 10,613 lbs/yr** **TMDL = 0 + 8.7 lbs/day + 20.4 lbs/day + 0 = 29.1 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

2.2 SEDIMENT

The available data suggest that aquatic life and fish in Clancy Creek are impaired by siltation/sediment. The following sections present the required TMDL elements for these pollutants. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that they are adequate for making relative comparisons, they should not be used directly as quantity estimates.

2.2.1 Sources of Sediment in the Clancy Creek Watershed

As shown in Figure 2-6, the primary anthropogenic sources of sediment in the Clancy Creek watershed, in order of importance, are streambank erosion, timber harvest, unpaved roads, urban development, and non-system roads/trails. Streambank erosion was primarily caused by riparian grazing, stream channelization from road encroachment, historic mine tailings piles, and channel encisement. Throughout much of the segment length, Clancy Creek Road (unpaved) is directly adjacent to the stream. The close proximity of the road to the stream prohibits sufficient riparian buffer width establishment to intercept road based sediment. Due to the lack of buffer width, removal of road shoulder vegetation from road grading activities, and the inherent erodibility of the granitic geology, road sediment is readily transported to Clancy Creek. Sediment from silvicultural activities is largely confined to mining claims in the upper watershed where riparian buffer width is insufficient to intercept all related eroded sediment. Urban development is confined within the downstream area of the watershed where new residential construction is occurring. Non-system roads and trails were observed in the upper watershed. These roads/trails are a problematic sediment source because no run-off mitigation structures have been constructed, and they are typically located on steep topography, frequently near watercourses.

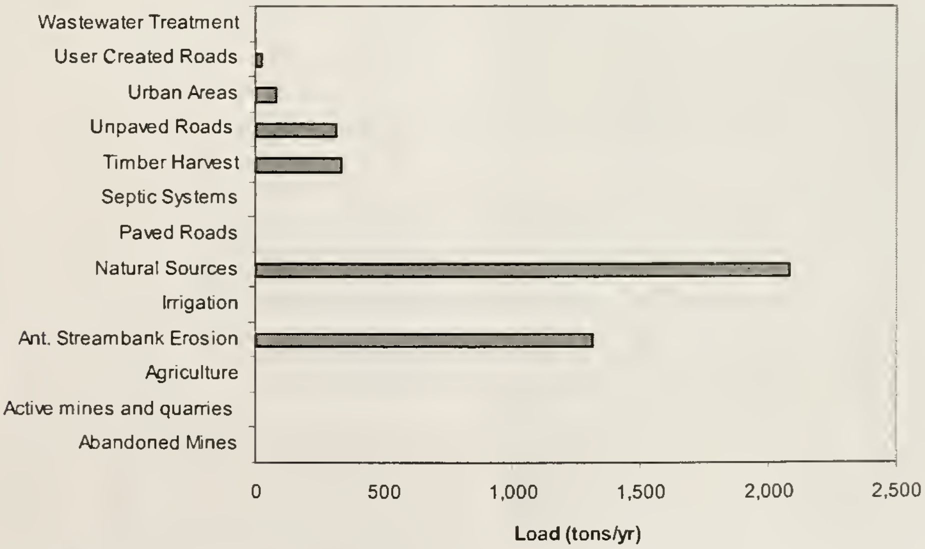

Figure 2-6. Total annual sediment load from all potentially significant sediment sources in the Clancy Creek Watershed.

2.2.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 2-7. Based on the results of the source assessment (Section 2.2.1), the recommended implementation strategy to address the sediment problem in Clancy Creek is to reduce sediment loading from the primary anthropogenic sediment sources – streambank erosion, dirt roads, and timber harvest. As shown in Table 2-7, the hypothesis is that an overall, watershed scale sediment load reduction of 40 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current timber harvest, dirt roads, anthropogenic bank erosion, urban areas, and non-system roads by 97, 60, 81, 80, and 100 percent, respectively.

Table 2-7. TMDL, Allocations, and Margin of Safety for Clancy Creek - Siltation.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Anthropogenic Streambank Erosion	1,315	81	250	It is estimated that there are 13.5 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	28	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	333	97	10	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	318	60	127	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	83	80	17	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed including vegetated buffer strips, engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	2,077	81	404		
	Natural Sources	2,082	0	2,082	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Clancy Creek Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**4,159**	**40**	**2,486**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 404 lbs/yr + 2,082 lbs/yr + 0 = 2,486 lbs/yr** **TMDL = 0 + 1.1 lbs/day + 5.7 lbs/day + 0 = 6.8 lbs/day**					

3.0 CORBIN CREEK

Corbin Creek from the headwaters to the mouth (Segment MT41I006_090, 2.5 miles) was listed as impaired on the Montana 1996 303(d) list because of suspended solids, metals, pH, salinity/total dissolved solids/chlorides, and other inorganics. Aquatic life, coldwater fisheries, agriculture, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, aquatic life, fishery, agriculture, industrial, recreational, and drinking water beneficial uses were listed as impaired because of metals, pH, suspended solids, and thermal modifications. The additional analyses and evaluations described in Volume I found that sediment (suspended solids), arsenic, cadmium, copper, lead, zinc, and salinity/TDS are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.7 of the Volume I Report). There were insufficient credible data to determine if thermal modifications are impairing beneficial uses. Additional monitoring for temperature is proposed in Appendix H.

Conceptual restoration strategies and the required TMDL elements for sediment, metals (i.e., arsenic, cadmium, copper, lead, and zinc), and salinity/TDS are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

3.1 METALS

The available water chemistry data suggest that aquatic life and fish in Corbin Creek are impaired by arsenic, cadmium, copper, lead, and zinc. The following sections present the required TMDL elements for these pollutants. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

3.1.1 Sources of Metals in the Corbin Creek Watershed

Besides anthropogenic sediment-associated metals sources, historical hard rock mining activities in the watershed are significant contributors of metals to Corbin Creek. Most of the drainage area falls within the Colorado mining district of Montana, with a small part of the headwaters in the Clancy district. The MBMG Abandoned and Inactive Mines database reports mineral location, surface, surface-underground, and underground mining activities in the watershed. The historical mining types include placer mining. In the past, these mines produced copper, silver, lead, zinc, and gold. Two of the mines in the basin are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites: Bertha and Alta mines – both in the Colorado mining district portion of the watershed. As was mentioned, recent mine reclamation efforts have taken place in the watershed. In 2000, approximately 154,000 cubic yards of spoil were removed from the drainage. Several portals and a deep vertical shaft were sealed. A repository approximately of eight acres in size was constructed on a ridge adjacent to the site and the spoil was encapsulated in an impervious liner and buried to eliminate any leaching into the surface or underground water systems. The entire site was re-seeded with a native grass mixture. Modeled sources and their metals loadings to Corbin Creek are presented in Figure 3-1 through Figure 3-5.

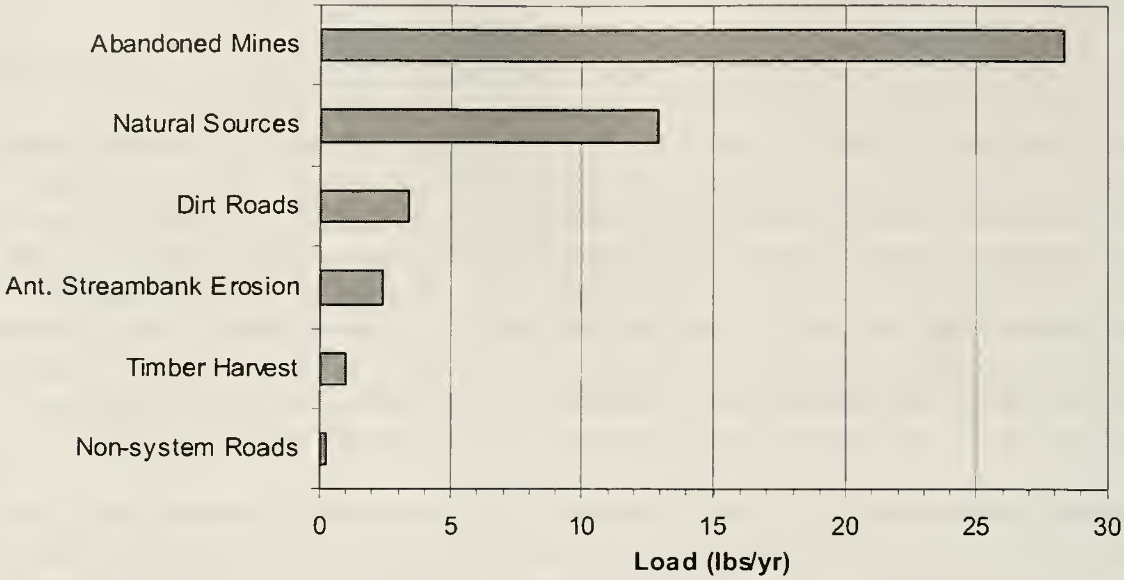

Figure 3-1. Sources of arsenic loadings to Corbin Creek.

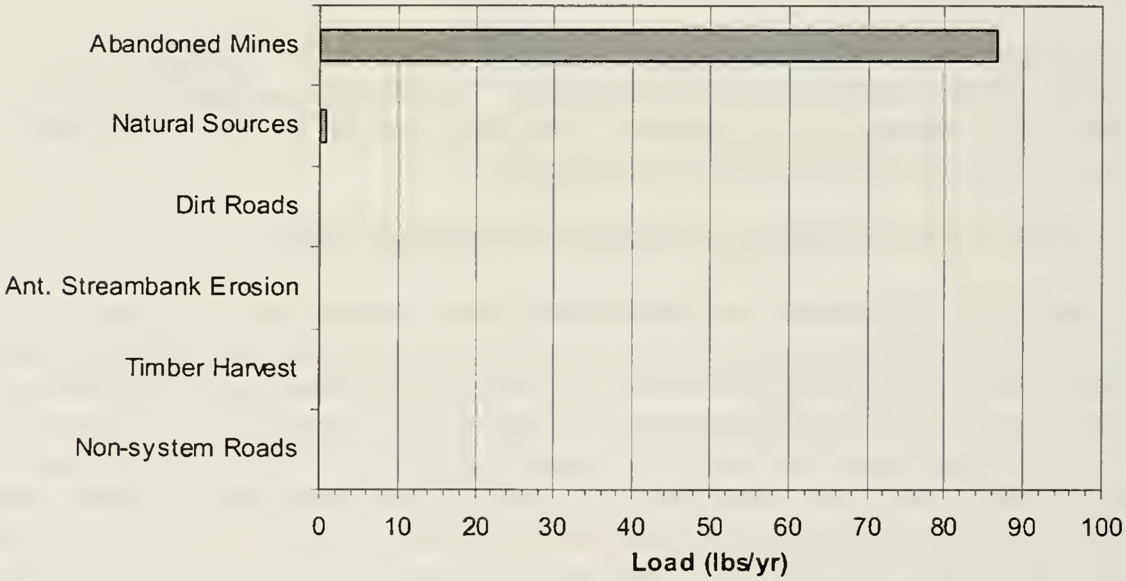

Figure 3-2. Sources of cadmium loadings to Corbin Creek.

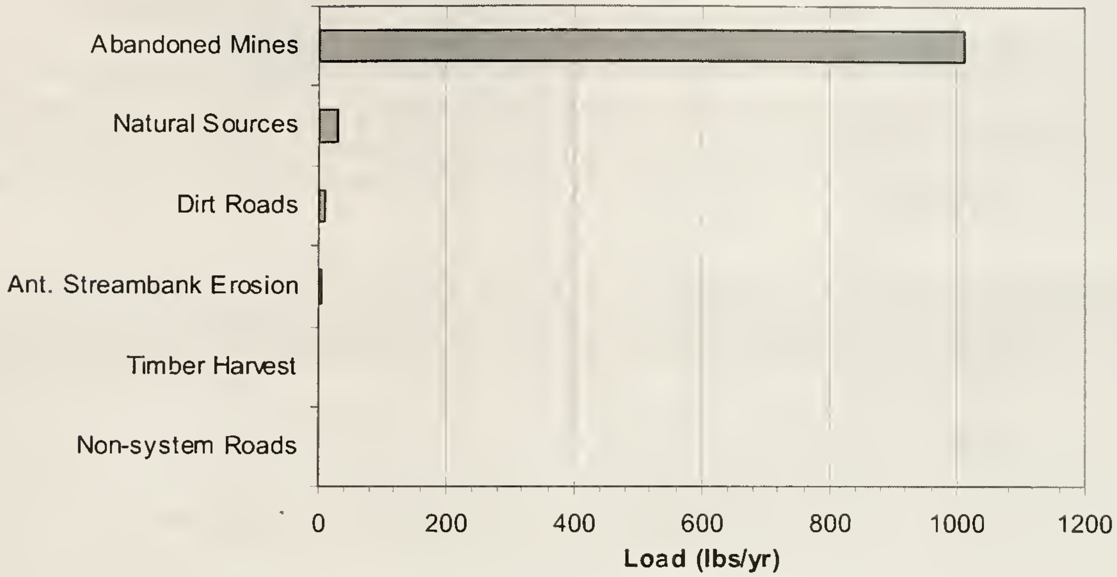

Figure 3-3. Sources of copper loadings to Corbin Creek

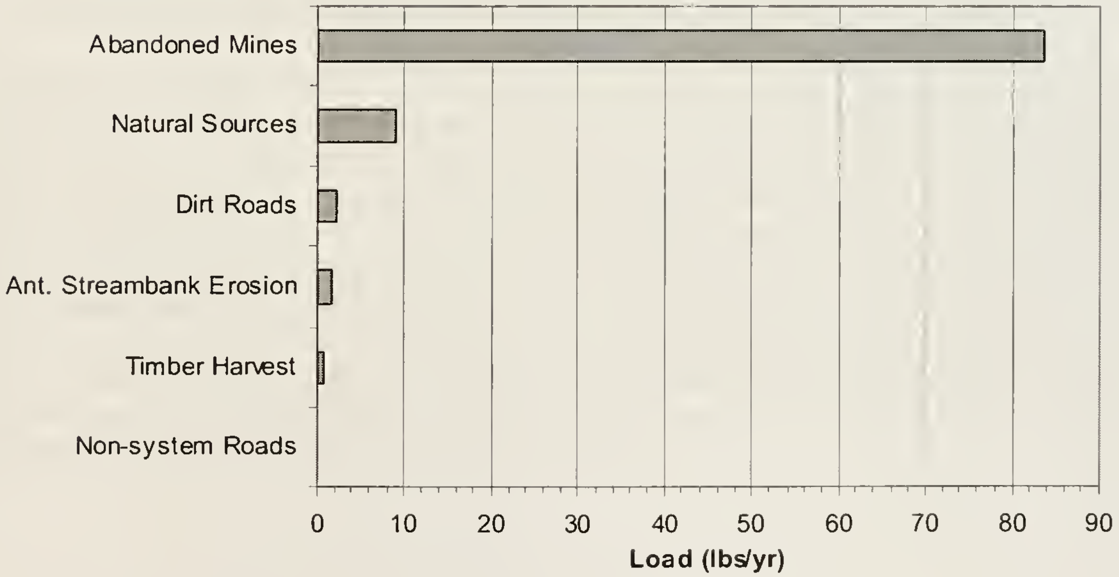

Figure 3-4. Sources of lead loadings to Corbin Creek.

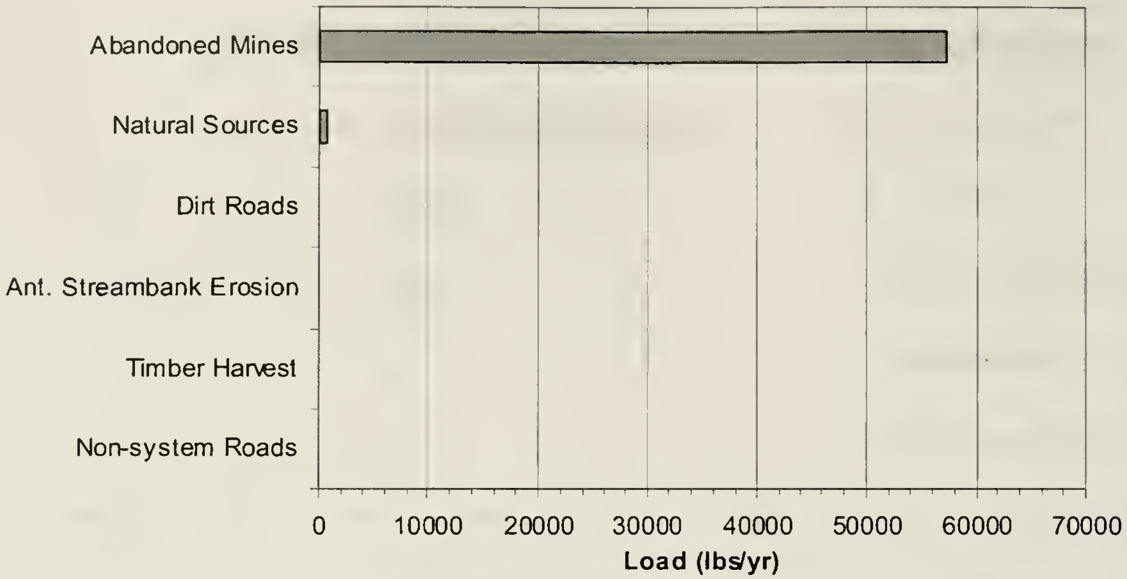

Figure 3-5. Sources of zinc loadings to Corbin Creek.

3.1.2 Water Quality Goals/Targets

The ultimate goal of the metals TMDLs is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Corbin Creek are presented in Table 3-1.

Table 3-1. Montana numeric surface water quality standards for metals in Spring Creek.

Parameter	Aquatic Life (acute) (μg/L)[a]	Aquatic Life (chronic) (μg/L)[b]	Human Health (μg/L)[a]
Arsenic (TR)	340	150	10[d]
Cadmium (TR)	8.95 at 400 mg/L hardness[c]	0.75 at 400 mg/L hardness[c]	5
Copper (TR)	51.0 at 400 mg/L hardness[c]	29.8 at 400 mg/L hardness[c]	1,300
Lead (TR)	468.3 at 400 mg/L hardness[c]	18.2 at 400 mg/L hardness[c]	15
Zinc (TR)	392.6 at 400 mg/L hardness[c]	392.6 at 400 mg/L hardness[c]	2,000

Note: TR = total recoverable.

[a] Maximum allowable concentration.

[b] No 4-day (96-hour) or longer period average concentration may exceed these values.

[c] The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).

[d] The human health standard for arsenic is currently 18 μg/L, but will change to 10 μg/L in 2006.

3.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 3-2 through Table 3-6. Based on the results of the source assessment (Section 3.1.1), the recommended implementation strategy to address the metals problem in Corbin Creek is to continue to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 3-2 through Table 3-6, the hypothesis is that an overall, watershed scale metals load reduction of 25, 97, 89, 66, and 97 percent for arsenic, cadmium, copper, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from historical mining sources by 23, 98, 92, 73, and 99 percent for arsenic, cadmium, copper, lead, and zinc, respectively. These loads and corresponding load reductions represent water quality conditions based on based on limited water quality data taken on the summer of 2003.

Table 3-2. TMDL, Allocations, and Margin of Safety for Corbin Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	28.4	23	21.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied (see Table 3-7). After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	2.4	92	0.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 92% (see Table 3-7), thereby reducing sediment associated metals loads from streambank erosion by 92%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.3	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-systém roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	1.0	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. [1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	3.4	60	1.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	35.5	34	23.3		
	Natural Sources	12.9	0	12.9	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		48.4	25	36.2		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 23.3 lbs/yr + 12.9 lbs/yr + 0 = 36.2 lbs/yr** **TMDL = 0 + 0.06 lbs/day + 0.04 lbs/day + 0 = 0.10 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 3-3. TMDL, Allocations, and Margin of Safety for Corbin Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	86.6	98	2.0	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied (see Table 3-7). After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	0.1	92	0.0	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 92% (see Table 3-7), thereby reducing sediment associated metals loads from streambank erosion by 92%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.1	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.2	60	0.1	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	87.0	98	2.1		
	Natural Sources	0.7	0	0.7	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		87.7	97	2.8		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 2.1 lbs/yr + 0.7 lbs/yr + 0 = 2.8 lbs/yr** **TMDL = 0 + 0.005 lbs/day + 0.002 lbs/day + 0 = 0.007 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 3-4. TMDL, Allocations, and Margin of Safety for Corbin Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	1,012.0	92	80.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied (see Table 3-7). After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	5.5	92	0.4	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 92% (see Table 3-7), thereby reducing sediment associated metals loads from streambank erosion by 92%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.6	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	2.3	97	0.1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. [1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	7.9	60	3.1	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1028.3	92	84.4		
	Natural Sources	30.2	0	30.2	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of copper in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**1058.5**	**89**	**114.6**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 84.4 lbs/yr + 30.2 lbs/yr + 0 = 114.6 lbs/yr** **TMDL = 0 + 0.23 lbs/day + 0.08 lbs/day + 0 = 0.31 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 3-5. TMDL, Allocations, and Margin of Safety for Corbin Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	83.6	72	23.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied (see Table 3-7). After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	1.6	92	0.1	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 92% (see Table 3-7), thereby reducing sediment associated metals loads from streambank erosion by 92%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.2	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.7	97	0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2.3	60	0.9	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	88.4	73	24.2		
	Natural Sources	9.0	0	9.0	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**97.4**	**66**	**33.2**		
TMDL	TMDL = WLA + LA + Natural + MOS TMDL = 0 + 24.2 lbs/yr + 9.0 lbs/yr + 0 = 33.2 lbs/yr TMDL = 0 + 0.07 lbs/day + 0.02 lbs/day + 0 = 0.09 lbs/day					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 3-6. TMDL, Allocations, and Margin of Safety for Corbin Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	57,293.9	98	859.4	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied (see Table 3-7). After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	130.6	92	10.5	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 92% (see Table 3-7), thereby reducing sediment associated metals loads from streambank erosion by 92%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	14.3	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	53.4	97	1.6	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	186.4	60	74.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	57,678.6	98	946.1	▨	▨
	Natural Sources	714.6	0	714.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of zinc in the Corbin Creek Watershed.	
Margin of Safety	▨	NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	▨
Total[1]	▨	**58,393.2**	**97**	**1,660.7**	▨	▨
TMDL	**TMDL = WLA + LA + Natural + MOS TMDL = 0 + 946.1 lbs/yr + 714.6 lbs/yr + 0 = 1,660.7 lbs/yr TMDL = 0 + 2.6 lbs/day + 1.9 lbs/day + 0 = 4.5 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

3.2 SALINITY/TOTAL DISSOLVED SOLIDS

As discussed in Section 3.1, beneficial uses in Corbin Creek are impaired by metals, and load reductions are necessary to meet water quality standards. The Volume I report also found that salinity/total dissolved solids (TDS) are impairing beneficial uses in Corbin Creek. However, the reason for the salinity/TDS impairment appears to be due primarily to dissolved metal concentrations. Metals are usually one small portion of the total dissolved solids in a stream. However, high metals concentrations (as seen in Corbin Creek) also result in elevated total dissolved solids and salinity. The metals data for Corbin Creek show that trace metals make up an unusually large proportion of the total dissolved solids in Corbin Creek. Arsenic, cadmium, copper, lead, and zinc make up almost 2 percent of the total dissolved solids in the stream – three orders of magnitude more than in other surveyed streams in the Lake Helena watershed (see Volume I report). Iron (although not sampled) is also most likely very high as well, because red precipitates were noted in the stream during sampling.

This evidence, combined with the lack of traditional salinity/TDS sources (e.g., saline seeps, irrigation returns, or oil/gas wells) suggests that metals concentrations in Corbin Creek are the primary cause of the salinity/TDS impairment. As such, there is no need at this time for a salinity/TDS TMDL, as the salinity impairment should be addressed with the metals TMDLs (see Section 3.1).

3.3 SEDIMENT

The available data suggest that aquatic life and fish in Corbin Creek are impaired by siltation/sediment. The following sections present the required TMDL elements for these pollutants. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

3.3.1 Sources of Sediment in the Corbin Creek Watershed

As shown in Figure 3-6, the primary anthropogenic sources of sediment in the Corbin Creek watershed, in order of sediment load are: unpaved roads, anthropogenic streambank erosion, abandoned mines, timber harvest, and non-system roads/trails.

Throughout much of its segment length, Corbin Creek Road (unpaved) is directly adjacent to the stream. The close proximity of the road to the stream channel, combined with a lack of any significant riparian vegetation in the lower watershed results in large quantities road based sediment being delivered to the stream. Additionally, a large portion of the total road length in the watershed is steep and generates significant sediment loads. However, between the preliminary source assessment in 2003 and the secondary source assessment conducted during the summer of 2005, a steep “switch-back” section of road was graveled, helping to reduce erosion. Nonetheless, additional lengths of steep, un-graveled road grade are present and continue to deliver sediment and in isolated locations in the upper watershed large gullies have developed.

Observed streambank erosion throughout this segment is largely the result of riparian grazing, stream channelization and historic mining activity. Abandoned mines contribute 16 percent of the total Corbin Creek anthropogenic sediment load. This load is related to two abandoned mines, the Blackjack and the Bertha, which is a high priority mine partially reclaimed by Montana DEQ. Model results indicate Bertha continues to produce notable sediment quantities. Minimal timber harvest activities are occurring in the Corbin watershed, but modeled data suggest that active sediment delivery is occurring. Sediment from silvicultural activities is largely confined to mining claims in the central watershed. Non-system roads/trails were observed in the central and upper watershed, these are mostly related to historic mining activity. These roads/trails are a problematic sediment source because they are typically located in steep topography where run-off diversion structures were not constructed.

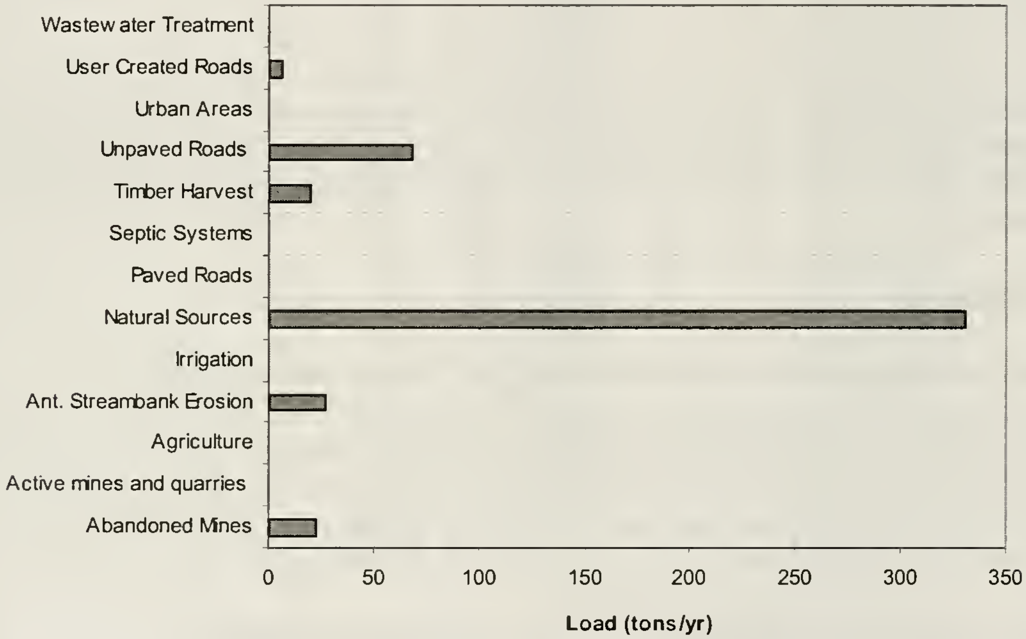

Figure 3-6. Total annual sediment load from all potentially significant sediment sources in the Corbin Creek Watershed.

3.3.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume 1, Section 3.1.3.

3.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 3-7. Based on the results of the source assessment (Section 3.3.1), the recommended implementation strategy to address the siltation problem in Corbin Creek is to reduce sediment loading from the primary anthropogenic sediment sources – unpaved roads, anthropogenic streambank erosion, abandoned mines, timber harvest, and non-system roads. As shown in Table 3-7, the hypothesis is that an overall, watershed scale sediment load reduction of 23 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current unpaved roads, anthropogenic streambank erosion, abandoned mines, timber harvest, and non-system roads by 60, 92, 79, 97, and 100 percent, respectively.

Table 3-7. TMDL, Allocations, and Margin of Safety for Corbin Creek – Siltation.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	23	71	7	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%.	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	27	92	2	It is estimated that there are 0.7 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	6	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	20	97	1	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate. The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Unpaved Roads	68	60	27	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix C of the Volume I Report).	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	144	77	37		
	Natural Sources	331	0	331	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Corbin Creek Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		475	23	368		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 37 lbs/yr + 331 lbs/yr + 0 = 368 lbs/yr** **TMDL = 0 + 0.10 lbs/day + 0.9 lbs/day + 0 = 1.0 lbs/day**					

4.0 GOLCONDA CREEK

Golconda Creek from the headwaters to the mouth (Segment MT411006_070, 3.7 miles) was listed as impaired on the Montana 1996 303(d) list because of metals, suspended solids, turbidity, and unknown toxicity. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, aquatic life, fishery, and drinking water beneficial uses were listed as impaired because of metals. The additional analyses and evaluations described in Volume I found that sediment (suspended solids and turbidity), cadmium and lead are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.6 of the Volume I Report).

Conceptual restoration strategies and the required TMDL elements for sediment and metals (i.e., cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

4.1 METALS

The limited water chemistry data suggest that Golconda Creek is impaired by cadmium and lead. TMDLs are presented in the following sections to address the cadmium and lead impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix C).

4.1.1 Sources of Metals in the Golconda Creek Watershed

Besides anthropogenic sediment-associated metals sources, relevant sources of metals in the stream are the historical mining activities in the watershed. During source assessment efforts, old mining areas were observed in tributary drainages to the west of the main stem of Golconda Creek, and significant mining disturbances were observed on private lands near the main stem. The entire drainage area of the stream falls within the Alhambra mining district of Montana. The MBMG Abandoned and Inactive Mines database reports surface-underground, prospect, and underground mining activities in the watershed. The historical mining types include lode mining. In the past these mines produced copper, silver, lead, gold, and zinc. The State of Montana's inventory of mine sites shows three mines in the drainage: Buckeye, Golconda, and Big Chief. The last of these three is closest to the stream and once produced lead, zinc, gold, and silver. None of the mines in the basin is listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. Modeled sources and their metals loadings to Golconda Creek are presented in Figure 4-1 and Figure 4-2.

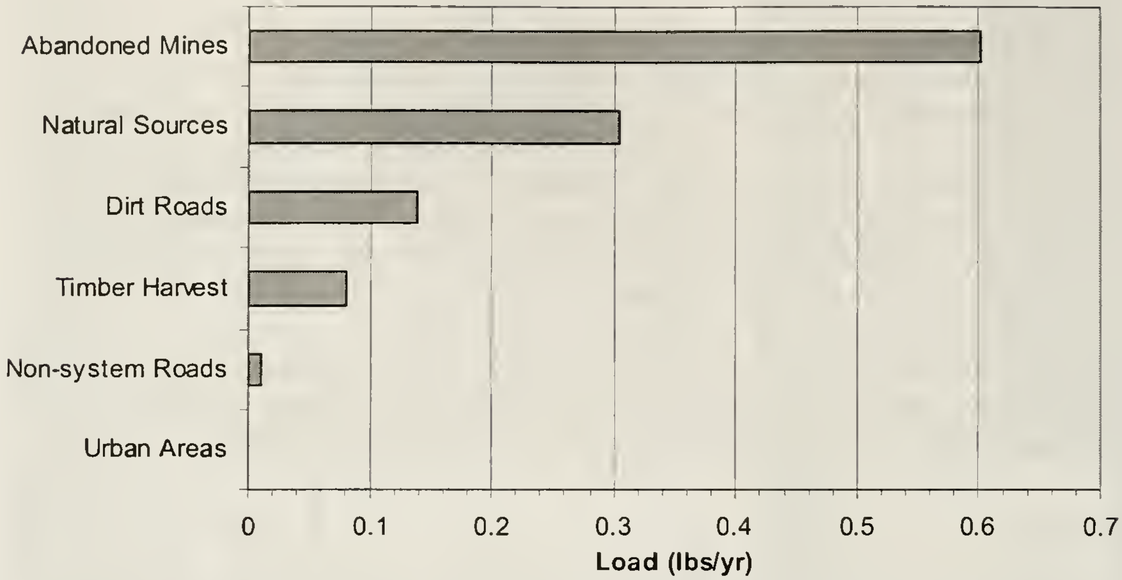

Figure 4-1. Sources of cadmium loadings to Golconda Creek.

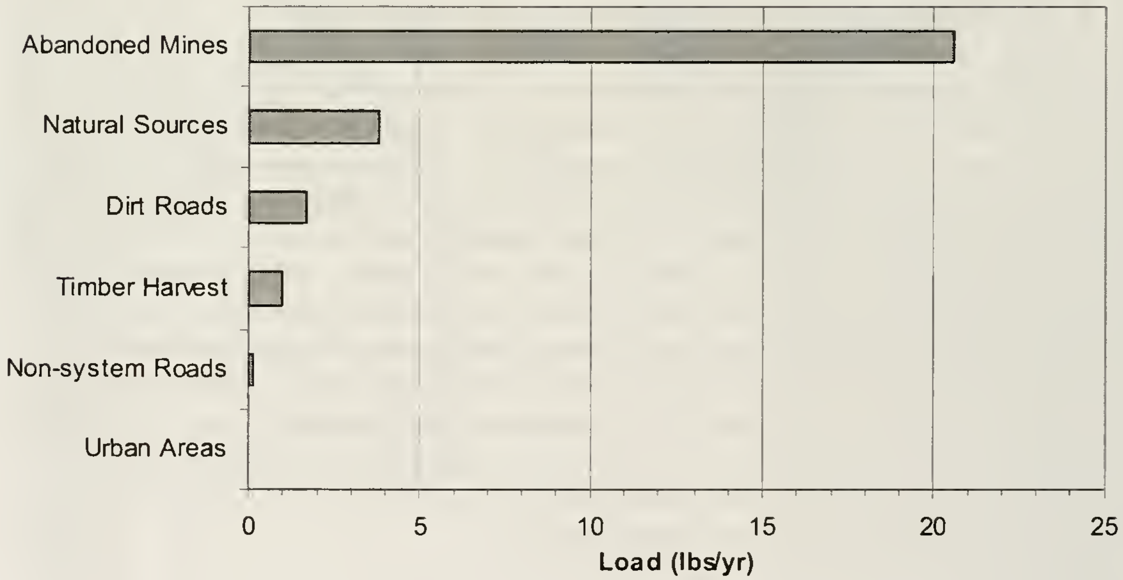

Figure 4-2. Sources of lead loadings to Golconda Creek.

4.1.2 Water Quality Goals/Targets

The ultimate goal of the metals TMDLs is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in the Golconda Creek are presented in Table 4-1.

Table 4-1. Montana numeric surface water quality standards for metals in Golconda Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Cadmium (TR)	0.8 at 38.5 mg/L hardness[c]	0.1 at 38.5 mg/L hardness[c]	5
Lead (TR)	23.9 at 38.5 mg/L hardness[c]	0.9 at 38.5 mg/L hardness[c]	15

Note: TR = total recoverable.
[a] Maximum allowable concentration.
[b] No 4-day (96-hour) or longer period average concentration may exceed these values.
[c] The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).

4.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 4-2 and Table 4-3. Based on the results of the source assessment (Section 4.1.1), the recommended implementation strategy to address the metals problem in Golconda Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 4-2 and Table 4-3, the hypothesis is that an overall, watershed scale metals load reduction of 41 and 77 percent for cadmium and lead respectively will result in achievement of the applicable water quality standards. Golconda Creek already meets applicable water quality standards for arsenic, copper, and zinc. The proposal for achieving the load reduction is to reduce loads from historical mining sources by 49 and 92 percent for cadmium and lead.

Table 4-2. TMDL, Allocations, and Margin of Safety for Golconda Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.6	49	0.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Non-system Roads	0.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.1	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.1	60	0.1	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	0.8	50	0.4		
	Natural Sources	0.3	0	0.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Golconda Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		1.1	41	0.7		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 0.4 lbs/yr + 0.3 lbs/yr + 0 = 0.7 lbs/yr** **TMDL = 0 + 0.0011 lbs/day + 0.0008 lbs/day + 0 = 0.0019 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 4-3. TMDL, Allocations, and Margin of Safety for Golconda Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	20.6	92	1.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Non-system Roads	0.1	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	1.0	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1.7	60	0.7	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	23.4	89	2.5		
	Natural Sources	3.8	0	3.8	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Golconda Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		27.2	77	6.3		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 2.5 lbs/yr + 3.8 lbs/yr + 0 = 6.3 lbs/yr** **TMDL = 0 + 0.007 lbs/day + 0.010 lbs/day + 0 = 0.017 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

5.0 JENNIE'S FORK FROM THE HEADWATERS TO THE MOUTH

Jennie's Fork from the headwaters to the mouth (Segment MT41I006_210, 1.2 miles) was listed as impaired on the Montana 1996 303(d) list because of siltation and metals. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, there were insufficient credible data to evaluate beneficial uses. The additional analyses and evaluations described in Volume I found that sediment (siltation) and lead are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.3.1 of the Volume I Report).

Conceptual restoration strategies and the required TMDL elements for sediment and lead are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

5.1 METALS

The limited water column samples suggest that Jennie's Fork is impaired by lead. A TMDL is presented in the following sections to address the lead impairment. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

5.1.1 Sources of Metals in the Jennie's Fork Watershed

Besides anthropogenic sediment-associated metals sources, significant contributors of metals to the stream segment are historical hard rock mining activities in the upper watershed. The watershed falls within the Marysville mining district. The MBMG Abandoned and Inactive Mines database reports mineral location mining activities in the watershed. The historical mining type is lode mining. In the past these mines produced gold, silver, and lead. One mine in the watershed, Bald Mountain, is listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. During the source assessment conducted by EPA in 2003 as a part of the TMDL project, it was learned that Jennie's Fork's point of origin is a mine shaft on Mount Belmont. The state has conducted significant reclamation work at this location and mining was active at this particular site until the late 1990s. Modeled sources and their lead loadings to Jennie's Fork are presented in Figure 5-1.

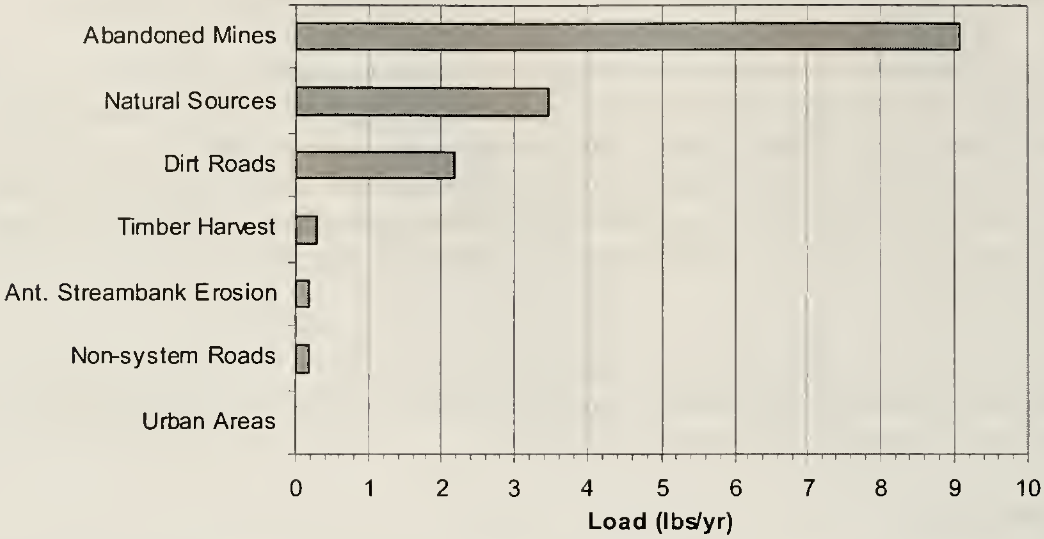

Figure 5-1. Sources of lead loadings to Jennie's Fork.

5.1.2 Water Quality Goals/Targets

The ultimate goal of the lead TMDL is to attain and maintain the applicable Montana numeric standard. Montana water quality metals standards for lead are dependent on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Jennie's Fork are presented in Table 5-1.

Table 5-1. Montana numeric surface water quality standards for metals in Jennie's Fork.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Lead (TR)	118.7 at 135.8 mg/L hardness[c]	4.6 at at 135.8 mg/L hardness[c]	15

Note: TR = total recoverable.
[a] Maximum allowable concentration.
[b] No 4-day (96-hour) or longer period average concentration may exceed these values.
[c] The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).

5.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 5-2. Based on the results of the source assessment (Section 5.1.1), the recommended implementation strategy to address the metals problem in Jennie's Fork is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 5-2, the hypothesis is that an overall, watershed scale metals load reduction of 46 percent for lead will result in achievement of the applicable water quality standards. Jennie's Fork already meets applicable water quality standards for arsenic, cadmium, copper and zinc. The proposal for achieving the load reduction is to reduce loads from mining sources by 57 percent for lead.

Table 5-2. TMDL, Allocations, and Margin of Safety for Jennie's Fork – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	9.1	57	3.9	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	0.2	44	0.1	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 44% (see Table 5-3), thereby reducing sediment associated metals loads from streambank erosion by 44%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.2	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.3	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2.2	60	0.9	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 5-3).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	12.0	59	4.9		
	Natural Sources	3.5	0	3.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Jennie's Fork Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**15.5**	**46**	**8.4**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 4.9 lbs/yr + 3.5 lbs/yr + 0 = 8.4 lbs/yr** **TMDL = 0 + 0.013 lbs/day + 0.010 lbs/day + 0 = 0.023 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

5.2 SEDIMENT

Based on the weight of evidence, cold-water fishery and aquatic life beneficial uses in Jennie's Fork are impaired by siltation (see Volume I Report). A TMDL is presented in the following sections to address the siltation impairment. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

5.2.1 Sources of Sediment in the Jennie's Fork Watershed

As shown in Figure 5-2, the primary anthropogenic sources of sediment in the Jennie's Fork watershed, in order of sediment load are unpaved roads, timber harvest, non-system roads, and anthropogenic streambank erosion.

The Jennie's Fork watershed has a high road density related to the town of Marysville, historic mining activity and the Great Divide ski area (all unpaved roads). During the sediment source assessment significant quantities of sediment were observed entering Jennie's Fork from the ski area parking lot during spring snowmelt run-off from the area's ski runs. Timber harvest activities have occurred throughout the upper watershed on mining claims and for the creation of ski runs at Great Divide. Non-system roads are associated with ski area and/or historic mining activities. Anthropogenic streambank erosion in this segment is largely the result of grazing impacts, road encroachment, stream channelization and historic mining activity.

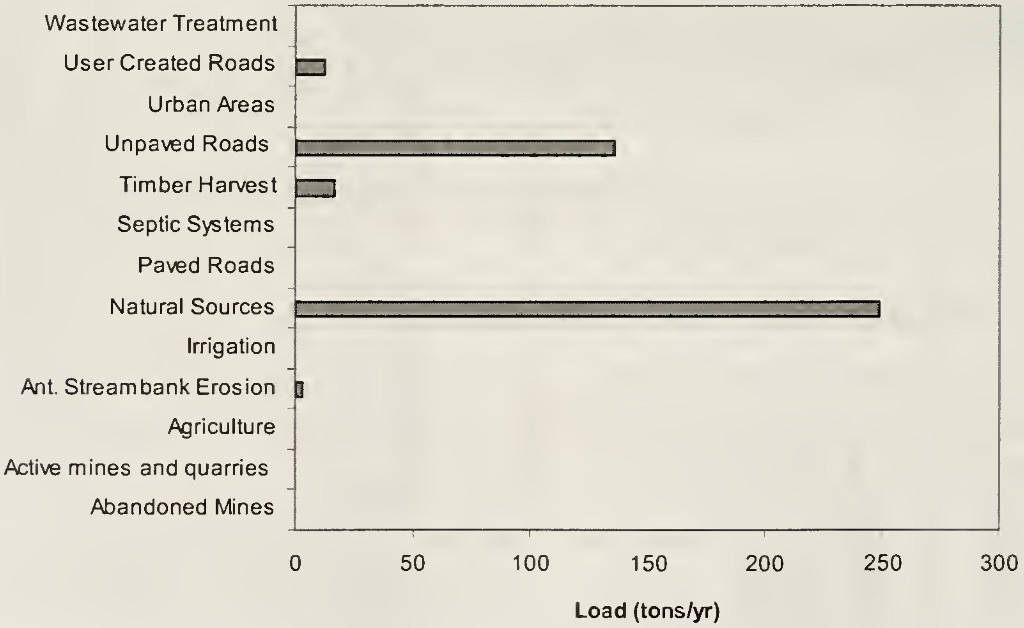

Figure 5-2. Total annual sediment load from all potentially significant sediment sources in the Jennie's Fork Watershed.

5.2.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

5.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 5-3. Based on the results of the source assessment (Section 5.2.1), the recommended implementation strategy to address the siltation problem in Jennie's Fork is to reduce sediment loading from the primary anthropogenic sediment sources – unpaved roads, timber harvest, non-system roads anthropogenic streambank erosion. As shown in Table 5-3, the hypothesis is that an overall, watershed scale sediment load reduction of 27 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current unpaved roads, timber harvest, non-system roads, and anthropogenic streambank erosion by 60, 97, 100, and 44 percent, respectively.

Table 5-3. TMDL, Allocations, and Margin of Safety for Jennie's Fork – Siltation.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
	Anthropogenic Streambank Erosion	3	44	1.7	It is estimated that there are 0.2 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	13	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	17	97	0.5	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	136	60	54.4	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix C of the Volume I Report).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	169	67	57	▨	▨
	Natural Sources	249	0	249	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Jennie's Fork Watershed.	
Margin of Safety	▨	NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	▨
Total	▨	**418**	27	**306**	▨	▨
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 57 lbs/yr + 249 lbs/yr + 0 = 306 lbs/yr** **TMDL = 0 + 0.16 lbs/day + 0.68 lbs/day + 0 = 0.84 lbs/day**					

6.0 LAKE HELENA

Lake Helena (Segment MT411007_010) was listed as impaired because of metals, nutrients, suspended solids, and thermal modifications on the Montana 1996 303(d) list. Aquatic life, coldwater fisheries, and recreation uses were the listed impaired beneficial uses. On subsequent 303(d) lists (2000, 2002, and 2004), lead and arsenic were the only listed causes of impairment, and only for drinking water uses. Reassessment of the listed pollutants using a weight of evidence approach found that metals are impairing aquatic life and fishery beneficial uses. There was insufficient information to determine if suspended solids and thermal modifications are impairing beneficial uses (see Volume I report). Conceptual restoration strategies and the required TMDL elements for metals are presented in the following subsections.

Available data also suggests that nutrients are decreasing water clarity and increasing the incidence of algal blooms in Lake Helena. However, insufficient data are available to determine the nutrient concentration threshold, above which beneficial uses in Lake Helena would be impaired. Given that model simulations indicate that nutrient loading in the Lake Helena Watershed is increasing, and water quality conditions are predicted to deteriorate, a pro-active TMDL is presented herein for nutrients in Lake Helena. As described below, an adaptive management strategy is proposed to revise the Lake Helena nutrient TMDL in the future based on future data collection efforts.

6.1 METALS

The limited water chemistry data suggest that Lake Helena is impaired by arsenic and lead. TMDLs are presented in the following sections to address the arsenic and lead impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

6.1.1 Sources of Metals in the Lake Helena Watershed

Waterborne contaminants originating within many of the 303(d) listed stream drainages are ultimately transported to Lake Helena. Metals sources for most of these major tributaries are summarized in Chapters 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, and 14 of this Appendix (Appendix A). Local sediment sources also contribute to an increase in arsenic loading to Lake Helena. In addition, contaminated bottom sediment is a potential metals source. These sources are discussed in Appendix F (LSPC modeling) and Appendix C of the Volume I Report. Modeled sources and their metals loadings to Lake Helena are presented in Figure 6-1 and Figure 6-2.

6.1.2 Water Quality Goals/Targets

The ultimate goal of the metals TMDLs is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for lead is dependant on the ambient water hardness and can therefore vary by water body. The target concentrations for metals in Lake Helena are presented in Table 6-1.

Table 6-1. Montana numeric surface water quality standards for metals in Lake Helena.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10[d]
Lead (TR)	157.6 at 169.7 mg/L hardness[c]	6.1 at 169.7 mg/L hardness[c]	15

Note: TR = total recoverable.

[a] Maximum allowable concentration.

[b] No 4-day (96-hour) or longer period average concentration may exceed these values.

[c] The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).

[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

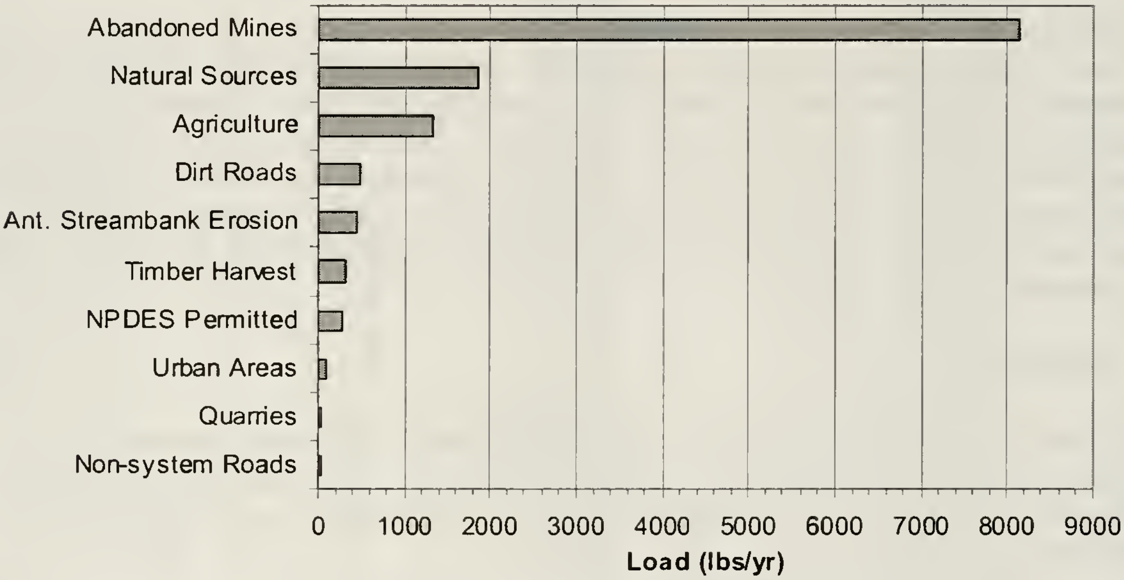

Figure 6-1. Sources of arsenic loadings to Lake Helena.

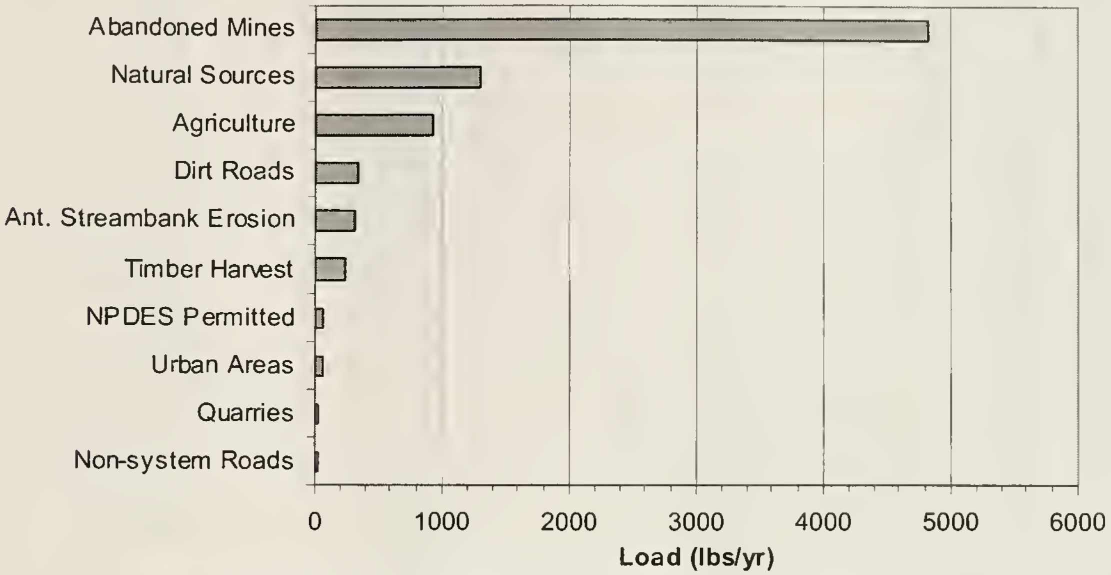

Figure 6-2. Sources of lead loadings to Lake Helena.

6.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations, and margin of safety are presented in Table 6-2 and Table 6-3. Based on the results of the source assessment (Section 6.1.1) the recommended implementation strategy to address the metals problem in Lake Helena is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 6-2 and Table 6-3, the hypothesis is that an overall, watershed scale metals load reduction of 61 and 66 percent for arsenic and lead, respectively, will result in achievement of the applicable water quality standards. Lake Helena already meets applicable water quality standards for cadmium, copper, and zinc. The proposal for achieving the load reduction is to reduce loads from mining sources by 68 and 77 percent for arsenic and lead.

Table 6-2. TMDL, Allocations, and Margin of Safety for Lake Helena – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	8,129.6	68	2,619.7	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	1,325.5	90	127.4	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	446.9	82	79.1	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	38.5	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	38.8	0	38.8	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	325.7	97	10.4	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	502.6	60	201.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	94.1	80	19.1	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	10,901.7	72%	3,095.5		
	Natural Sources	1,859.5	0	1,859.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
	All Point Sources	271.0	45	149.2	The permitted point sources of metals include MT Tunnels Mines and ASARCO. The current permit limits have been applied.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		13,032.2	61	5,104.2		
TMDL	TMDL = WLA + LA + Natural + MOS TMDL = 149.2 + 3,095.5 lbs/yr + 1,859.5 lbs/yr + 0 = 5,104.2 lbs/yr TMDL = 0.41 + 8.48 lbs/day + 5.09 lbs/day + 0 = 13.98 lbs/day					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 6-3. TMDL, Allocations, and Margin of Safety for Lake Helena – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	4,833.9	77	1,100.7	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	925.5	90	88.9	Loading estimates for this source category assume that no BMPs have been applied The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	312.1	82	55.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	26.9	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	27.1	0	27.1	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	227.4	97	7.3	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery [1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land Thus the current timber harvest load from private lands may be over or underestimated
	Unpaved Roads	350.9	60	140.4	It is assumed that no BMPs are currently in place It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	65.7	80	13.3	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure The estimated load reductions may be an overestimate
	Total – All Anthropogenic Nonpoint Sources	6,769.5	79	1,432.9		
	Natural Sources	1,298.3	0	1,298.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled
Wasteload Allocation	**All Point Sources**	66.8	0	66.8	The permitted point sources of metals include MT Tunnels Mines and ASARCO The current permit limits have been applied.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs	
Total[1]		**8,134.6**	**66**	**2,798.0**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 66.8 + 1,432.9 lbs/yr + 1,298.3 lbs/yr + 0 = 2,798 lbs/yr** **TMDL = 0.18 + 3.92 lbs/day + 3.56 lbs/day + 0 = 7.66 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

6.2 NUTRIENTS

6.2.1 Limiting Nutrient

Nitrogen and phosphorus are the two elements most commonly limiting algal growth in lakes and streams. Some indication of whether nitrogen or phosphorus is growth limiting may be obtained by determining the weight ratio of the appropriate forms of nitrogen and phosphorus found in a river or lake, and comparing that with the stoichiometric ratio required for growth. Where the ratio of nitrogen to phosphorus is greater than 15:1, phosphorus is more likely limiting than nitrogen. If the ratio is less than 5:1, nitrogen is more likely limiting than phosphorus. If the ratio is less than 15 but greater than 5, either N or P could be limiting, or an N and P co-limitation could be present. For assessing nutrient limitations in streams, the N:P ratios are usually computed on the basis of the soluble inorganic forms of N and P (i.e. TSIN:SRP). For lakes, nutrient ratios are commonly computed on the basis of the total forms of N and P. This is because nutrients may cycle in lakes and become soluble over time or under certain physical and chemical conditions. Total N and total P relate better overall to seasonal and lake wide productivity.

It is important to know which nutrient is limiting such that control efforts can focus on the nutrient most likely causing the beneficial use impairments.

A review was performed of the available nitrogen and phosphorus data for Lake Helena. Four water column samples collected by the Montana Department of Environmental Quality in early August 2002 showed an average total N to total P ratio of 9.6:1, with a range from 8.5 to 10.3. Four samples collected by Land & Water Consulting in late August 2003 showed a TN:TP ratio of 2.7:1, with a range of 2.6 to 2.8. Three additional samples collected by Land & Water during runoff conditions in late June 2003 showed a TN:TP ratio of 9.3:1 with a range of 7.8 to 10.2. A fourth sample collected near the lake inlet produced a ratio of 50.5:1 due to a very low total P measurement, which may have been in error.

The Lake Helena nutrient ratio data presented above point to a conclusion that algae growth in the lake is either nitrogen limited (August 2003), or N and/or P limited (August 2002, June 2003). Based on these total nutrient ratio data, it can be concluded that the lake is not overwhelmingly phosphorus limited. Computing the N:P ratios using the soluble inorganic nutrient fractions suggests a stronger nitrogen limitation in Lake Helena, rather than a co- or P-limitation.

In the absence of a strong case for either N or P limitation, TMDLs are presented below for both nitrogen and phosphorus.

6.2.2 Nitrogen

6.2.2.1 Sources of Nitrogen in the Lake Helena Watershed

At the watershed scale (i.e., the entire Lake Helena Watershed), septic systems (29 percent), return flows from the Helena Valley Irrigation System (17 percent), municipal wastewater treatment facilities (11 percent), and urban areas (6 percent) comprise the most significant sources of total nitrogen (TN) (Figure 6-3). Also, in localized areas, TN loading from agricultural and single family residential sources may be far more significant than this source category appears to be at the watershed scale.

6.2.2.2 Water Quality Goals/Targets

Insufficient data are currently available to establish TN targets for Lake Helena. A strategy to establish targets in the future is presented in Volume II, Section 3.2.3.

6.2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

Since no concentration targets have been proposed for Lake Helena, it is assumed that the load reductions for Prickly Pear Creek (the largest tributary to Lake Helena) adequately approximate the necessary load reductions. A TN load reduction of 80 percent is therefore proposed as an interim load reduction goal. This will be revised in the future following the strategy presented in Volume II, Section 3.0.

The proposed approach acknowledges that it may not be possible to attain the an 80 percent TN load reduction, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality will continue to degrade if no action is taken to reduce loading. Therefore, the proposed approach seeks the maximum attainable nitrogen load reductions from non-point sources, includes a phased wasteload allocation to reduce point sources loads, and, in recognition of the fact that it a TN concentration target has not yet been established, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 6-4. The phased wasteload allocation is presented in Appendix I and the adaptive management strategy is presented in Volume II, Section 3.0. Finally, a summary of estimated loads, proposed reductions, and post-reduction loads for all sources considered in the TN analysis is presented in Table 6-5.

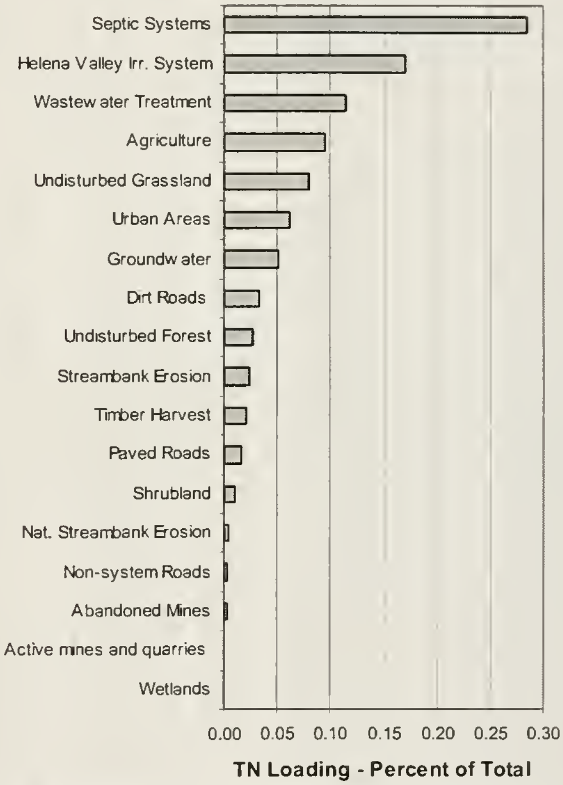

Figure 6-3. Percent of the total annual nitrogen load from all potentially significant nitrogen sources in the entire Lake Helena Watershed.

Table 6-4. TMDL, Allocations, and Margin of Safety for Lake Helena – Nitrogen.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.9	71	0.2	Nutrient loading from abandoned mines is primarily a function of associated sediment loading. Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%. Sediment-associated nitrogen will decrease accordingly (71%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated nitrogen reductions could be over or under estimated.
	Active Mines	0.4	0	0.4	BMPs for active mines were assumed to not be cost effective because the loads represent such a small fraction of the current overall loads.	Current loads from active mines are based on modeled storm water runoff and literature values for runoff concentrations The current loads are likely overestimated because DEQ reports that there has never been a discharge from the MT Tunnels Mine site (the only significant active mine in the watershed)
	Agriculture	33.2	88	3.9	Loading estimates for this source category assume that no BMPs have been applied The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	8.5	85	1.3	It is estimated that there are 82.8 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Helena Valley Irrigation District (HVID)	60.1	50	30.0	It is difficult to estimate potential load reductions from the HVID due to its unique and complex nature. No appropriate literature values are available. A 50 percent reduction has therefore been selected based on best professional judgment.	Estimates of current loads from the HVID are based on limited sampling data and potential load reductions are based on best professional judgment. Therefore, the estimated load and load reduction may be under or overestimated.
	Non-system Roads	0.9	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	5.7	30	4.0	An average nitrogen removal efficiency of 30% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	101.5	0.5	101.0	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 0.5% decrease in TN. Replacing failing septic systems with level 2 treatment could result in a 1.7% reduction in TN.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated. No specific data were available about the actual percentage of failing systems.
	Timber Harvest	7.6	97	0.2	It is assumed that nitrogen loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, nitrogen reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	11.5	60	4.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding nitrogen load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	21.8	30	15.3	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average nitrogen removal efficiency of 30% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	252.1	36	160.9		
	Natural Sources	60.9	0	60.9	It is assumed that the nitrogen loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	40.4	89	4.4	Nitrogen Point sources are listed in Table 6-5. The allocations for the WWTPs are based on the phased approach described in Appendix I. Load reductions for known failing lagoons are presented in Table 6-5. No allocations are proposed for lagoons thought to be operating as designed.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		353.4	36	226.2		
TMDL	**TMDL = WLA + LA + Natural + MOS TMDL = 4.4 + 160.9 tons/yr + 60.9 tons/yr + 0 = 226.2 tons/yr TMDL = 0.01 + 0.44 tons/day + 0.17 tons/day + 0 = 0.62 tons/day**					

Table 6-5. Estimated loads and load reductions for all sources of TN in the Lake Helena watershed.

Source Category	Source	Estimated TN Load (tons/yr)	Estimated Reductions (%)	Remaining Load (tons/yr)
Anthropogenic Nonpoint Sources	Timber Harvest	7.6	97%	0.2
	Unpaved Roads	11.5	60%	4.6
	Non-system Roads	0.9	100%	0.0
	Paved Roads	5.7	30%	4.0
	Active mines and quarries	0.4	0%	0.4
	Abandoned Mines	0.9	71%	0.2
	Agriculture	33.2	88%	3.9
	Urban Areas	21.8	30%	15.3
	Anthropogenic Streambank Erosion	8.5	85%	1.3
	Helena Valley Irrigation System	60.1	50%	30.0
	Septic Systems	101.5	0.5%	101.0
	Total Anthropogenic NPS Load	**252.1**	36%	**160.9**
Natural Nonpoint Sources	Fullgrowth Forest	9.5	0%	9.5
	Wetlands	0.1	0%	0.1
	Shrubland	3.5	0%	3.5
	Grassland	28.2	0%	28.2
	Nat. Streambank Erosion	1.6	0%	1.6
	Groundwater	18.0	0%	18.0
	Total Natural NPS Load	**60.9**	0%	**60.9**
Point Sources	City of Helena	31.8	92%	2.5[1]
	East Helena	6.5	97%	0.2[1]
	Evergreen Nursing Home	0.1	0%	0.1
	Treasure State Acres subdivision	0.1	50%	0.0
	Tenmile and Pleasant Valley subdivisions	0.8	21%	0.6
	Mountain View law enforcement academy	0.2	0%	0.2
	Eastgate Subdivision	0.1	0%	0.1
	Leisure Village mobile home park	0.8	20%	0.7
	Total Point Source	**40.4**	89%	**4.4**
Total	Totals	353.4	36%	226.2

[1] See Appendix I for a description of the phased wasteload allocation for these point sources.

Table 6-6. TMDL, Allocations, and Margin of Safety for Lake Helena – Phosphorus.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.2	71	0.1	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%. Sediment-associated phosphorus will decrease accordingly (71%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated phosphorus reductions could be over or under estimated.
	Active Mines	0.1	0	0.1	BMPs for active mines were assumed to not be cost effective because the loads represent such a small fraction of the current overall loads.	Current loads from active mines are based on modeled storm water runoff and literature values for runoff concentrations. The current loads are likely overestimated because DEQ reports that there has never been a discharge from the MT Tunnels Mine site (the only significant active mine in the watershed).
	Agriculture	7.2	89	0.8	Loading estimates for this source category assume that no BMPs have been applied The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	1.8	85	0.3	It is estimated that there are 48.0 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Helena Valley Irrigation District (HVID)	7.6	50	3.8	It is difficult to estimate potential load reductions from the HVID due to its unique and complex nature. No appropriate literature values are available. A 50 percent reduction has therefore been selected based on best professional judgment.	Estimates of current loads from the HVID are based on limited sampling data and potential load reductions are based on best professional judgment. Therefore, the estimated load and load reduction may be under or overestimated.
	Non-system Roads	0.2	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	0.6	50	0.3	An average phosphorus removal efficiency of 50% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	0.9	100	0.0	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 100% decrease in TP.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	1.6	97	0.1	It is assumed that phosphorus loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, phosphorus reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2.5	60	1.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding phosphorus load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	2.2	50	1.1	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average phosphorus removal efficiency of 50% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	24.9	70	7.6		
	Natural Sources	11.3	0.0	11.3	It is assumed that the phosphorus loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	15.0	88	1.8	Phosphorus point sources are listed in Table 6-7 The allocations for the WWTPs are based on the phased approach described in Appendix I. Load reductions for known failing lagoons are presented in Table 6-7. No allocations are proposed for lagoons thought to be operating as designed.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		51.2	60	20.7		
TMDL	**TMDL = WLA + LA + Natural + MOS TMDL = 1.8 tons/yr + 7.6 tons/yr + 11.3 tons/yr + 0 = 20.7 tons/yr TMDL = 0.01 + 0.02 tons/day + 0.03 tons/day + 0 = 0.06 tons/day**					

Table 6-7. Estimated loads and load reductions for all sources of TP in the Lake Helena watershed.

Source Category	Source	Estimated TP Load (tons/yr)	Estimated Reductions (%)	Remaining Load (tons/yr)
Anthropogenic Nonpoint Sources	Timber Harvest	1.6	97%	0.1
	Unpaved Roads	2.5	60%	1.0
	Non-system Roads	0.2	100%	0.0
	Paved Roads	0.6	50%	0.3
	Active mines and quarries	0.1	0%	0.1
	Abandoned Mines	0.2	71%	0.1
	Agriculture	7.2	89%	0.8
	Urban Areas	2.2	50%	1.1
	Anthropogenic Streambank Erosion	1.8	85%	0.3
	Helena Valley Irrigation System	7.6	50%	3.8
	Septic Systems	0.9	100%	0.0
	Total Anthropogenic NPS	**24.9**	**70%**	**7.6**
Natural Nonpoint Sources	Fullgrowth Forest	2.1	0%	2.1
	Wetlands	0.0	0%	0.0
	Shrubland	0.8	0%	0.8
	Grassland	6.1	0%	6.1
	Nat. Streambank Erosion	0.4	0%	0.4
	Groundwater	1.9	0%	1.9
	Total Natural NPS	**11.3**	**0%**	**11.3**
Point Sources	City of Helena	13.5	98%	0.3[1]
	East Helena	1.0	0%	1.0[1]
	Evergreen Nursing Home	0.0	0%	0.0
	Treasure State Acres subdivision	0.1	33%	0.1
	Tenmile and Pleasant Valley subdivisions	0.1	14%	0.1
	Mountain View law enforcement academy	0.1	0%	0.1
	Eastgate Subdivision	0.1	0%	0.1
	Leisure Village mobile home park	0.1	13%	0.1
	Total Point Source	**15.0**	**88%**	**1.8**
Total		**51.2**	**60%**	**20.7**

[1] See Appendix I for a description of the phased wasteload allocation for these point sources.

7.0 LUMP GULCH

Lump Gulch from the headwaters to the mouth (Segment MT41I006_130, 14.5 miles) was listed as impaired on the Montana 1996 303(d) list because of suspended solids and metals. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, aquatic life, fishery, and drinking water beneficial uses were listed as impaired because of cadmium, copper, lead, mercury, metals, and zinc. The additional analyses and evaluations described in Volume I found that sediment (suspended solids), cadmium, copper, lead, and zinc are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.13 of the Volume I Report). There were insufficient data to determine if mercury is impairing beneficial uses.

Conceptual restoration strategies and the required TMDL elements for sediment and metals (i.e., cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

7.1 METALS

The recent water chemistry data suggest that Lump Gulch is impaired by cadmium, copper, lead, and zinc. TMDLs are presented in the following sections to address the impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

7.1.1 Sources of Metals in the Lump Gulch Watershed

Besides anthropogenic sediment-associated metals sources, significant contributors of metals to the stream are historical mining activities in the upper watershed. The headwaters of the watershed fall within the Clancy mining district. The MBMG Abandoned and Inactive Mines database reports mineral location, placer, surface, and underground mining activities in the watershed. The historical mining types include placer, lode, and mill. In the past these mines produced lead, copper, zinc, silver, gold, and uranium. In the headwaters area there are over 10 historical hard rock mines, including 4 sites in Frohner Basin and the Clancy district— Nellie Grant, Frohner (two mines), and General Grant—that are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. The aerial photography assessment showed the drainage to be disrupted by historical mining dams at the Frohner Meadows Mine. The Helena National Forest documented along this stretch of the stream included road sediment delivery points, mine waste rock dumps, a mining dam, and channel incision. Modeled sources and their metals loadings to Lump Gulch are presented in Figure 7-1 through Figure 7-4.

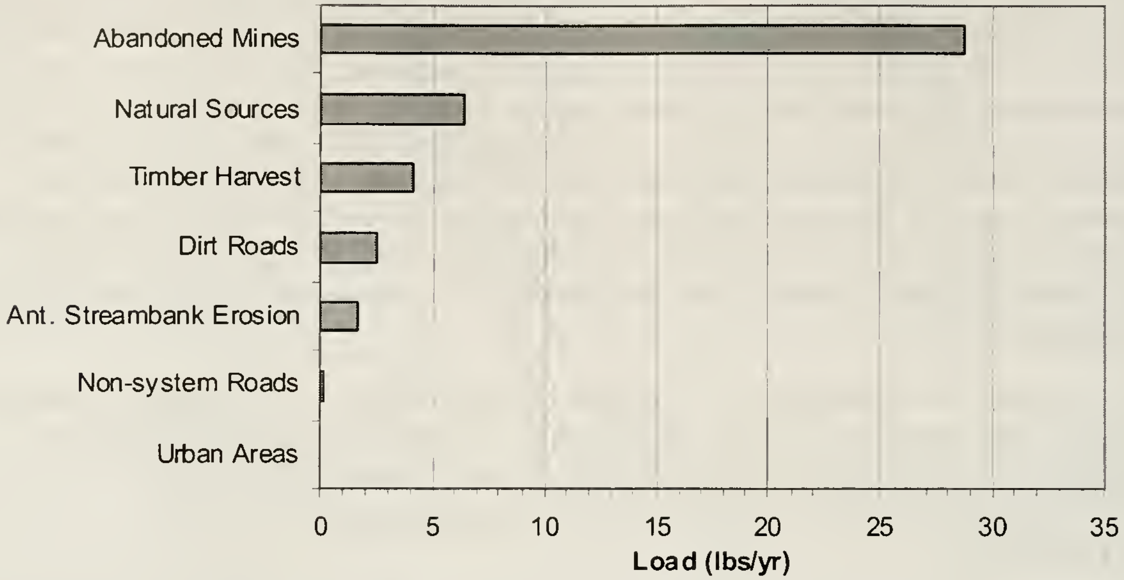

Figure 7-1. Sources of cadmium loadings to Lump Gulch.

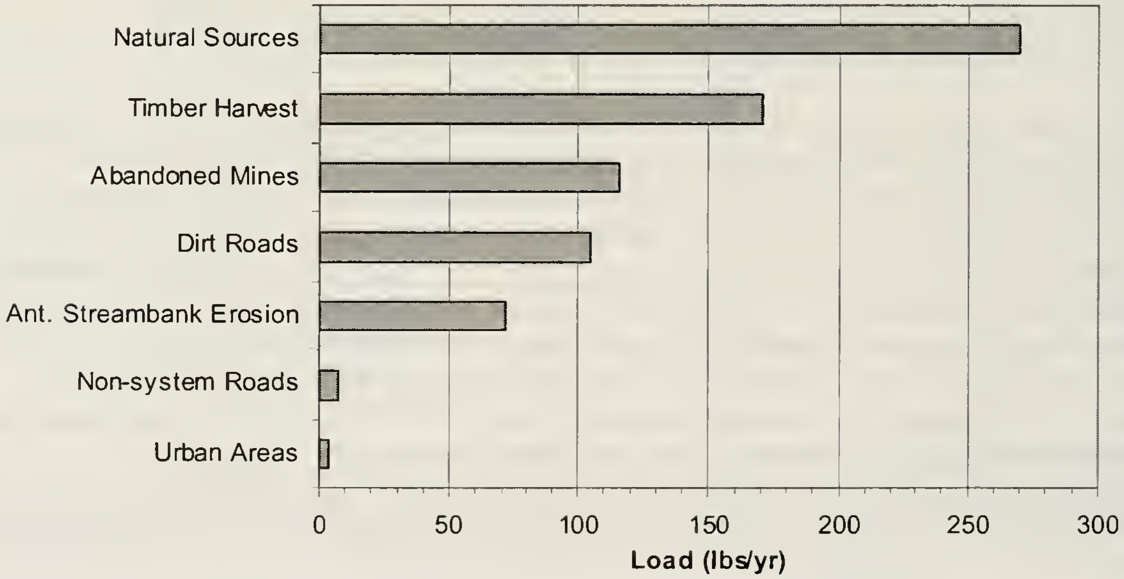

Figure 7-2. Sources of copper loadings to Lump Gulch.

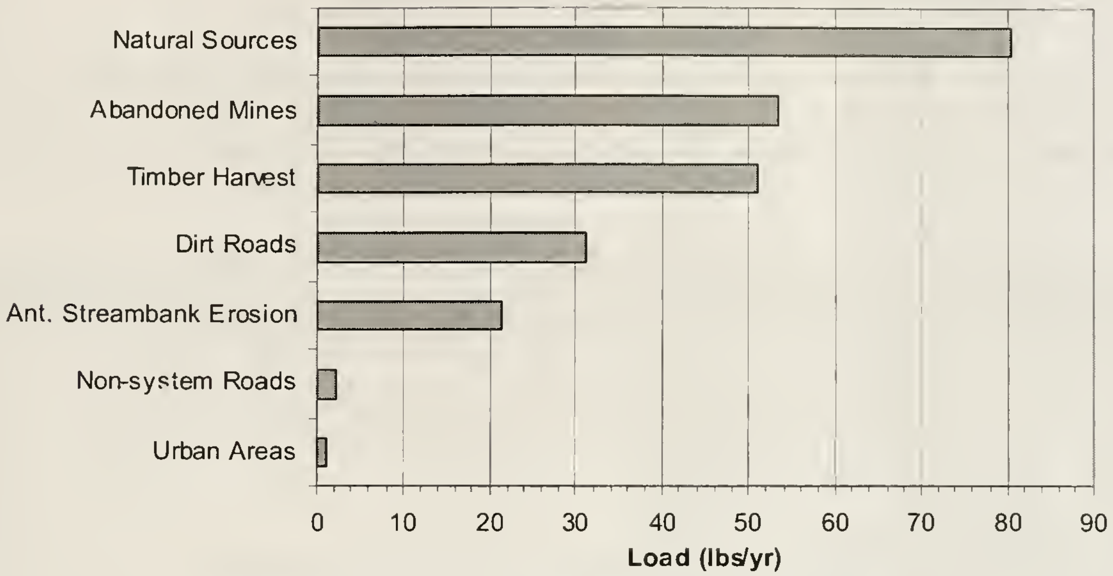

Figure 7-3. Sources of lead loadings to Lump Gulch.

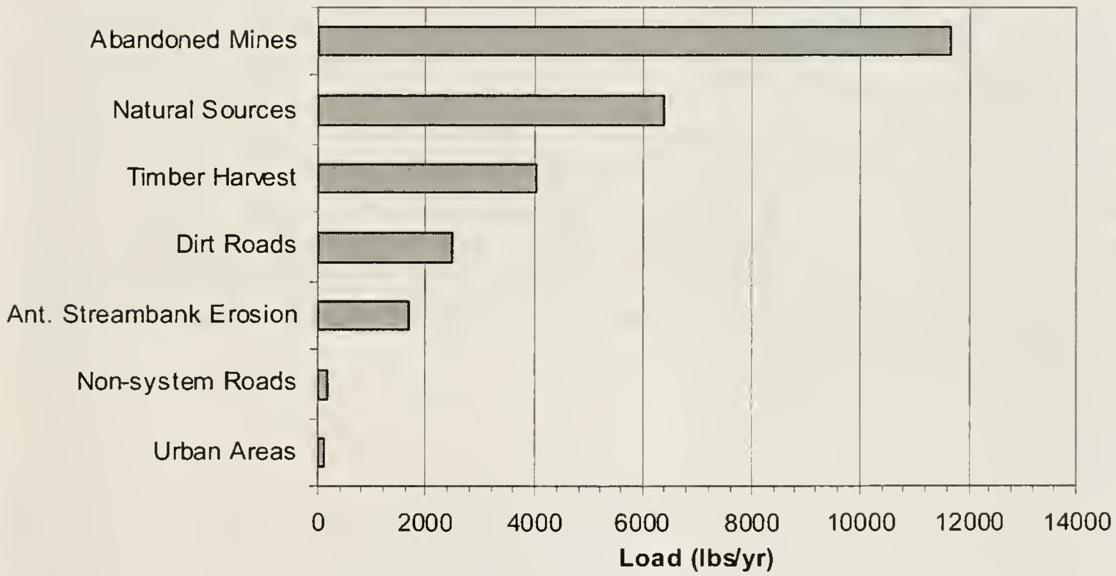

Figure 7-4. Sources of zinc loadings to Lump Gulch.

7.1.2 Water Quality Goals/Targets

The ultimate goal of the metals TMDLs is to attain and maintain the applicable Montana numeric standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Lump Gulch are presented in Table 7-1.

Table 7-1. Montana numeric surface water quality standards for metals in Lump Gulch.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Cadmium (TR)	1.1 at 51.4 mg/L hardness[c]	0.2 at 51.4 mg/L hardness[c]	5
Copper (TR)	7.4 at 51.4 mg/L hardness[c]	5.2 at 51.4 mg/L hardness[c]	1,300
Lead (TR)	34.6 at 51.4 mg/L hardness[c]	1.3 at 51.4 mg/L hardness[c]	15
Zinc (TR)	68.6 at 51.4 mg/L hardness[c]	68.6 at 51.4 mg/L hardness[c]	2,000

Note: TR = total recoverable.

[a] Maximum allowable concentration.

[b] No 4-day (96-hour) or longer period average concentration may exceed these values.

[c] The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).

[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

7.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 7-2 through Table 7-5. Based on the results of the source assessment (Section 7.1.1), the recommended implementation strategy to address the metals problem in Lump Gulch is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 7-2 through Table 7-5, the hypothesis is that an overall, watershed scale metals load reduction of 76, 39, 44, and 68 percent for cadmium, copper, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. Lump Gulch already meets applicable water quality standards for arsenic. The proposal for achieving the load reduction is to reduce loads from historical mining sources by 92, 0, 35, and 96 percent for cadmium, copper, lead, and zinc, respectively.

Table 7-2. TMDL, Allocations, and Margin of Safety for Lump Gulch – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	28.8	92	2.4	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	1.7	75	0.4	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 75% (see Table 7-6), thereby reducing sediment associated metals loads from streambank erosion by 75%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.2	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	4.1	96	0.1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2.5	60	1.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 7-6).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.1	80	0.0	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 7-6), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	37.4	90	3.9		
	Natural Sources	6.5	0	6.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Lump Gulch Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		43.9	76	10.4		
TMDL	TMDL = WLA + LA + Natural + MOS TMDL = 0 + 3.9 lbs/yr + 6.5 lbs/yr + 0 = 10.4 lbs/yr TMDL = 0 + 0.01 lbs/day + 0.02 lbs/day + 0 = 0.03 lbs/day					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 7-3. TMDL, Allocations, and Margin of Safety for Lump Gulch – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	116.0	0	116.0	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	72.1	75	18.0	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 75% (see Table 7-6), thereby reducing sediment associated metals loads from streambank erosion by 75%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	8.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	171.1	96	6.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	104.5	60	41.8	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 7-6).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	4.2	80	0.8	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 7-6), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	475.9	62	182.8		
	Natural Sources	270.0	0	270.0	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of copper in the Lump Gulch Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		745.9	39	452.8		
TMDL	TMDL = WLA + LA + Natural + MOS TMDL = 0 + 182.8 lbs/yr + 270.0 lbs/yr + 0 = 452.8 lbs/yr TMDL = 0 + 0.50 lbs/day + 0.74 lbs/day + 0 = 1.24 lbs/day					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 7-4. TMDL, Allocations, and Margin of Safety for Lump Gulch – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	53.5	35	34.9	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	21.5	75	5.4	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 75% (see Table 7-6), thereby reducing sediment associated metals loads from streambank erosion by 75%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	2.4	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	51.0	96	1.8	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	31.2	60	12.5	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 7-6).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.2	80	0.2	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 7-6), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	160.8	66	54.8	▨	▨
	Natural Sources	80.5	0	80.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Lump Gulch Watershed.	
Margin of Safety	▨	NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	▨
Total	▨	241.3	44	135.3	▨	▨
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 54.8 lbs/yr + 80.5 lbs/yr + 0 = 135.3 lbs/yr** **TMDL = 0 + 0.15 lbs/day + 0.22 lbs/day + 0 = 0.37 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 7-5. TMDL, Allocations, and Margin of Safety for Lump Gulch – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	11,676.7	96	506.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	1,707.3	75	426.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 75% (see Table 7-6), thereby reducing sediment associated metals loads from streambank erosion by 75%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	189.9	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	4,054.2	96	146.8	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2,476.6	60	990.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 7-6).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	99.2	80	19.8	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 7-6), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	20,203.9	90	2,090.6		
	Natural Sources	6,395.3	0	6,395.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of zinc in the Lump Gulch Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**26,599.2**	**68**	**8,485.9**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 2,090.6 lbs/yr + 6,395.3 lbs/yr + 0 = 8,485.9 lbs/yr** **TMDL = 0 + 5.7 lbs/day + 17.5 lbs/day + 0 = 23.2 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

7.2 SEDIMENT

The available data suggest that Warm Springs Creek is impaired by sediment (See Volume I Report). TMDLs are presented in the following sections to address the sediment impairments. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

7.2.1 Sources of Sediment in the Lump Gulch Watershed

As shown in Figure 7-5, the primary anthropogenic sources of sediment in the Lump Gulch watershed, in order of sediment load are: timber harvest, unpaved roads, anthropogenic streambank erosion, urban areas, abandoned mines, and non-system roads/trails.

Significant timber harvest activities have occurred in the Lump Gulch watershed on private land, state land (DNRC school trust land) and BLM property. Model results suggest that sediment related to silvicultural activities within the watershed generate the greatest quantity of anthropogenically induced sediment. In the upper watershed, much of the timber harvest has occurred on mining claims; these units are typically harvested using a clear-cut silvicultural prescription. Throughout much of the central area of the segment length, Lump Gulch Road is directly adjacent to the stream. The erodible parent material, the high road usage, close proximity to the stream channel, and a narrow riparian buffer throughout much of the upper watershed results in large quantities road based sediment being delivered to the stream. Residential areas populate the lower third of the watershed. Modeled sediment load from this land use was 140 tons. Observed streambank erosion is largely the result of riparian grazing, road encroachment, stream channelization and historic mining activity. Three abandoned mines, Nellie Grant, Frohner, and Yama Group are present in the upper watershed. DEQ reclaimed Nellie Grant, and is consequently generating minimal sediment. Frohner and Yama remain un-reclaimed and continue to produce sediment. Non-system roads/trails were observed in the central and upper watershed. These roads/trails are mostly related to historic mining activity and public land areas, and are a problematic sediment source because run-off mitigation structures were not constructed, and they are typically located in steep topography, frequently near watercourses.

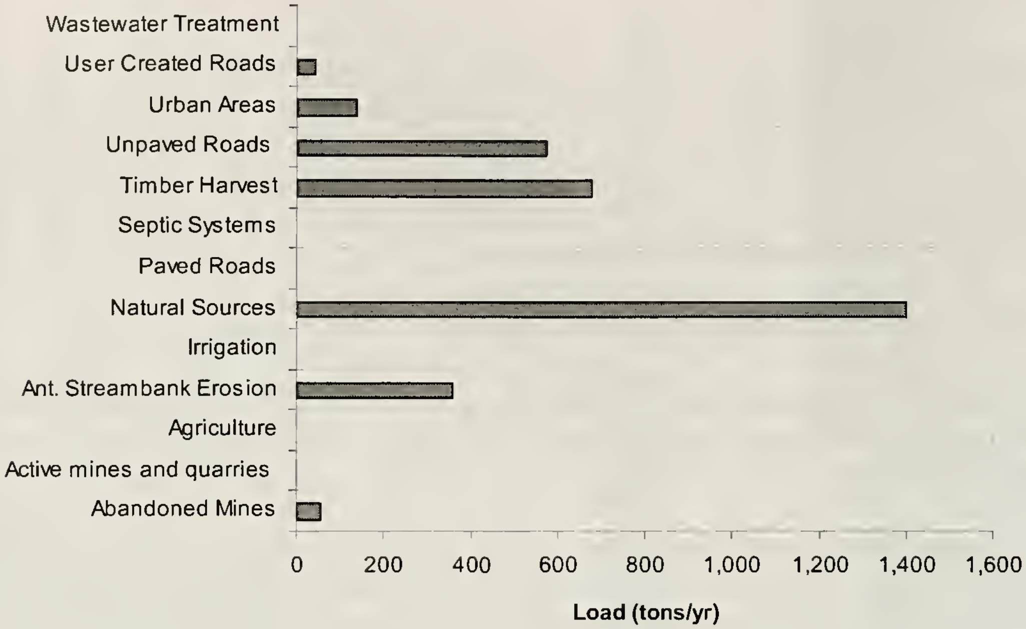

Figure 7-5. Total annual sediment load from all potentially significant sediment sources in the Lump Gulch Watershed.

7.2.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

7.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 7-6. Based on the results of the source assessment (Section 7.2), the recommended implementation strategy to address the siltation problem in Lump Gulch is to reduce sediment loading from the primary anthropogenic sediment sources – timber harvest, unpaved roads, anthropogenic streambank erosion, urban areas, abandoned mines, and non-system roads. As shown in Table 7-6, the hypothesis is that an overall, watershed scale sediment load reduction of 45 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current timber harvest, unpaved roads, anthropogenic streambank erosion, urban areas, abandoned mines, and non-system roads by 97, 60, 75, 80, 79, and 100 percent respectively.

Table 7-6. TMDL, Allocations, and Margin of Safety for Lump Gulch – Siltation.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	55	79	12	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 79%.	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	359	75	90	It is estimated that there are 6.1 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	44	100	0	All non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads. Therefore, this load reduction may be an overestimate.
	Timber Harvest	681	97	20	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	576	60	230	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	140	80	28	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,855	81	380		
	Natural Sources	1,400	0	1,400	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Lump Gulch Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total[1]		3,255	45	1,780		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 380 lbs/yr + 1,400 lbs/yr + 0 = 1,780 lbs/yr** **TMDL = 0 + 1.1 lbs/day + 3.8 lbs/day + 0 = 4.9 lbs/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

8.0 PRICKLY PEAR CREEK

Six segments of Prickly Pear Creek have appeared on various Montana 303(d) lists: Prickly Pear Creek from Headwaters to Spring Creek (MT41I006_060), Prickly Pear Creek from Spring Creek to Lump Gulch (MT41I006_050), Prickly Pear Creek from Lump Gulch to Wylie Drive (MT41I006_040), Prickly Pear Creek from Wylie Drive to Helena Wastewater Treatment Plant Discharge (MT41I006_030), Prickly Pear Creek from Helena WWTP Discharge Ditch to Lake Helena (MT41I006_020), and Prickly Pear Creek from Lake Helena to Hauser Reservoir (MT41I006_010). Impaired uses and causes of impairment varied by segment and by 303(d) list.

Volume I presented additional data and analyses for the 303(d) listed segments in Prickly Pear Creek. Using a weight of evidence approach, the impairment status of each segment was updated. Segment MT41I006_010 of Prickly Pear Creek was not evaluated in Volume I because it is located downstream of Lake Helena, and will therefore be addressed as part of the Hauser Lake TMDL Planning Area.

The following paragraphs summarize the 303(d) listings and Volume I analyses for each segment in Prickly Pear Creek:

- **Prickly Pear Creek from Headwaters to Spring Creek (MT411006_060)** – In 1996, the cold-water fishery use in this 8.7-mile headwater segment of Prickly Pear Creek was listed as threatened due to suspended solids and metals. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of metals. The additional analyses and evaluations described in Volume I found that lead and sediment (suspended solids) are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.1 of the Volume I Report).
- **Prickly Pear Creek from Spring Creek to Lump Gulch (MT411006_050)** – In 1996, aquatic life and cold-water fisheries beneficial uses in this 7-mile segment of Prickly Pear Creek were listed as impaired because of suspended solids and siltation. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of metals and siltation. The additional analyses and evaluations described in Volume I found that cadmium, lead, zinc, and sediment (suspended solids and siltation) are impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.2 of the Volume I Report).
- **Prickly Pear Creek from Lump Gulch to Wylie Drive (MT411006_040)** – In 1996, the aquatic life and cold-water fishery beneficial uses in this 11-mile segment of Prickly Pear Creek were listed as impaired because of metals. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of metals and siltation. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, copper, lead, zinc, and sediment (siltation) are impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.3 of the Volume I Report).
- **Prickly Pear Creek from Wylie Drive to Helena Wastewater Treatment Plant Discharge (MT411006_030)** – In 1996, the aquatic life, drinking water, and cold-water fishery beneficial uses in this 6.1-mile segment of Prickly Pear Creek were listed as impaired because of siltation, suspended solids, and metals. In 2002 and 2004, aquatic

life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of metals, nutrients, siltation, and thermal modifications. The additional analyses and evaluations described in Volume I found that arsenic, lead, nutrients, sediment (siltation and suspended solids), and thermal modifications are impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.4 of the Volume I Report).

- **Prickly Pear Creek from Helena WWTP Discharge Ditch to Lake Helena (MT411006_020)** – In 1996, the aquatic life, drinking water, and cold-water fishery beneficial uses in this 9.1-mile segment of Prickly Pear Creek were listed as impaired because of siltation, suspended solids, metals, nutrients, and unionized ammonia. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of siltation, metals, nutrients, thermal modifications, and unionized ammonia. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, lead, nutrients, sediment (suspended solids and siltation), and thermal modifications are impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.5 of the Volume I Report). Ammonia is not impairing beneficial uses, and therefore no TMDL will be presented.

Conceptual restoration strategies and the required TMDL elements for sediment, nutrients, thermal modifications, and metals (i.e., arsenic, cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix C, D, E, F, G, and K.

8.1 METALS

Water chemistry data suggest that Prickly Pear Creek is impaired by arsenic, cadmium, copper, lead, and zinc (See Volume I Report). TMDLs are presented in the following sections to address the metals impairments.

8.1.1 Sources of Metals in the Prickly Pear Creek Watershed

The following discussion will incorporate TMDL development for Prickly Pear Creek as a single, holistic system composed of the five 303(d) listed segments. The metals loads shown are cumulative and include the five listed Prickly Pear segments, as well as all other listed tributary segments. This includes Spring Creek, Clancy Creek, Corbin Creek, Golconda Creek, Jackson Creek, Lump Gulch, North Fork, Middle Fork, and main Warm Springs Creek, upper, middle and lower Tenmile Creek, Skelly Gulch, and Sevenmile Creek. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

Prickly Pear Creek from Headwaters to Spring Creek (MT411006_060) – A tributary stream and historical mining activities in the immediate drainage area comprise the most significant sources of metals to this stream segment. Golconda Creek flows into this segment and is a significant contributor of metals. Most of the drainage area falls within the Alhambra mining district, although there are sections of Elkhorn and Colorado mining districts in the basin. The Montana Bureau of Mines and Geology (MBMG) Abandoned and Inactive Mines database shows placer, mineral prospect, surface, surface-underground, and underground historical mining activities in the drainage area of the stream. The mining types listed include lode and placer. In the past, these mines produced silver, lead, zinc, manganese, molybdenum, and gold. None of the mines in the drainage area of this segment are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites.

Prickly Pear Creek from Spring Creek to Lump Gulch (MT411006_050) – Relevant sources of metals to the stream segment are upstream sources (MT411006_060), tributary streams, and historical mining activities in the immediate drainage area. The segment's upstream reach and tributaries (including Spring Creek, Clancy Creek, and Warm Springs Creek) are contributing metals loads. In addition, during field sampling efforts, spring seeps were noted entering Prickly Pear Creek from placer tailings piles along the stream. The immediate drainage area of the listed segment falls within the Alhambra and Clancy mining districts. The MBMG Abandoned and Inactive Mines database reports mineral location, surface, surface-underground, underground, and other, "unknown" mining activities in the immediate drainage area of the stream segment. The historical mining types include lode and placer. In the past these mines produced gold, silver, copper, lead, zinc, and uranium. None of the mines in the immediate drainage area of this segment are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites.

Prickly Pear Creek from Lump Gulch to Wylie Drive (MT411006_040) – Relevant sources of metals in the stream segment are upstream sources, tributary streams, and historical mining activities in the immediate drainage area. The segment's upstream reach (MT411006_050) and the tributary Lump Gulch contribute metals loads. The immediate drainage area falls within the Alhambra, Clancy, and Montana City mining districts. The MBMG Abandoned and Inactive Mines database reports mineral location, placer, processing plant, prospect, surface, surface-underground, and other, unknown mining activities in the immediate drainage area of the stream segment. The historical mining types include lode, mill, placer, quarry, and smelter. In the past these mines produced gold, silver, copper, and lead. None of the mines in the immediate drainage area of this segment are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. The ASARCO East Helena Lead Smelter is located in this subwatershed (NPDES Permit MT0030147) and is permitted to discharge arsenic, cadmium, copper, lead and zinc to the stream. Current permit limits are 1.140 mg/L for arsenic, 0.1374 mg/L for cadmium, 1.122 mg/L for copper, 0.239 mg/L for lead, and 0.77 mg/L for zinc.

Prickly Pear Creek from Wylie Drive to Helena Wastewater Treatment Plant Discharge (MT411006_030) – Upstream reaches comprise the primary contributors of metals to this segment.

Prickly Pear Creek from Helena WWTP Discharge Ditch to Lake Helena (MT411006_020) – Upstream reaches comprise the primary contributors of metals to this segment.

Modeled sources and their metals loadings to Prickly Pear Creek are presented in Figure 8-1 through Figure 8-5.

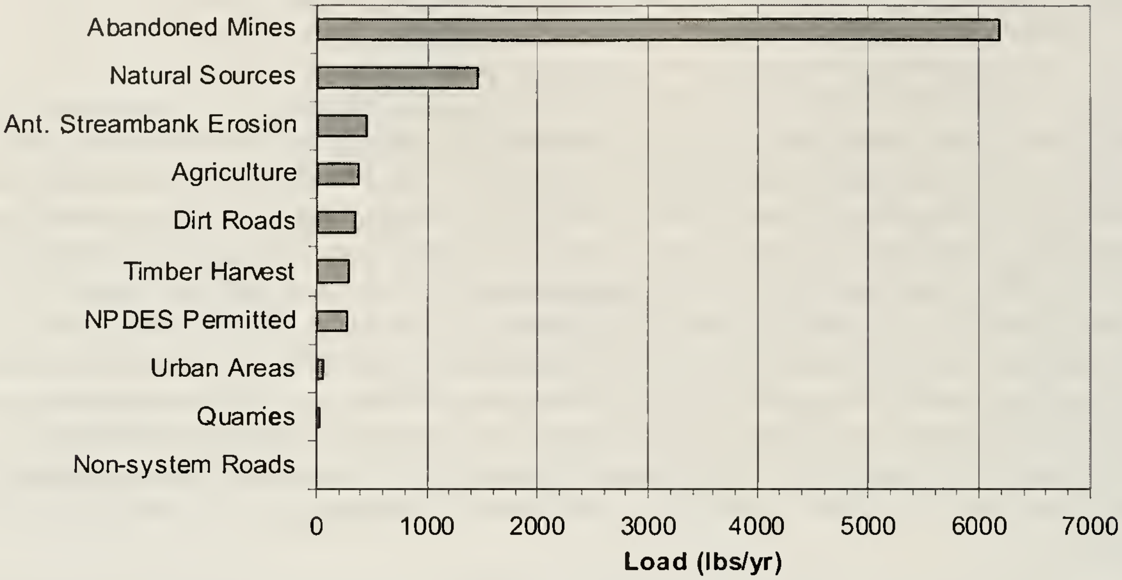

Figure 8-1. Sources of arsenic loadings to Prickly Pear Creek.

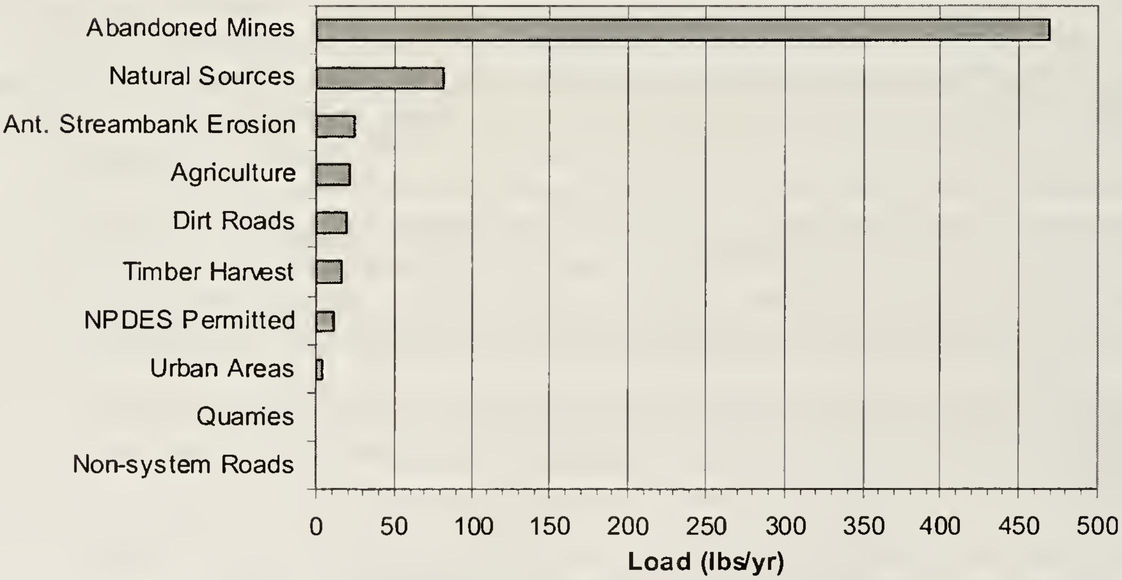

Figure 8-2. Sources of cadmium loadings to Prickly Pear Creek.

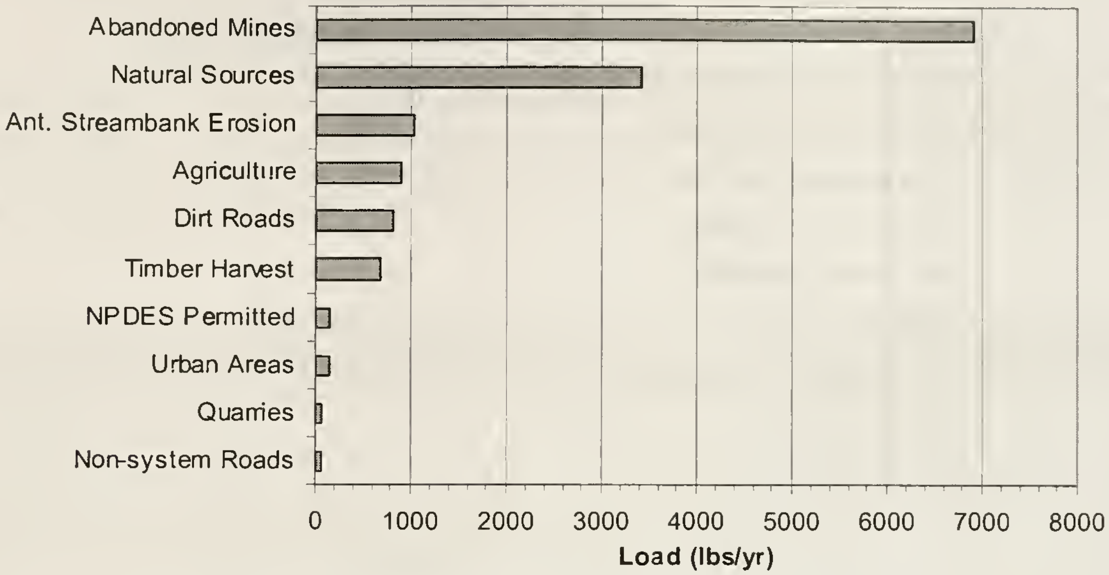

Figure 8-3. Sources of copper loadings to Prickly Pear Creek.

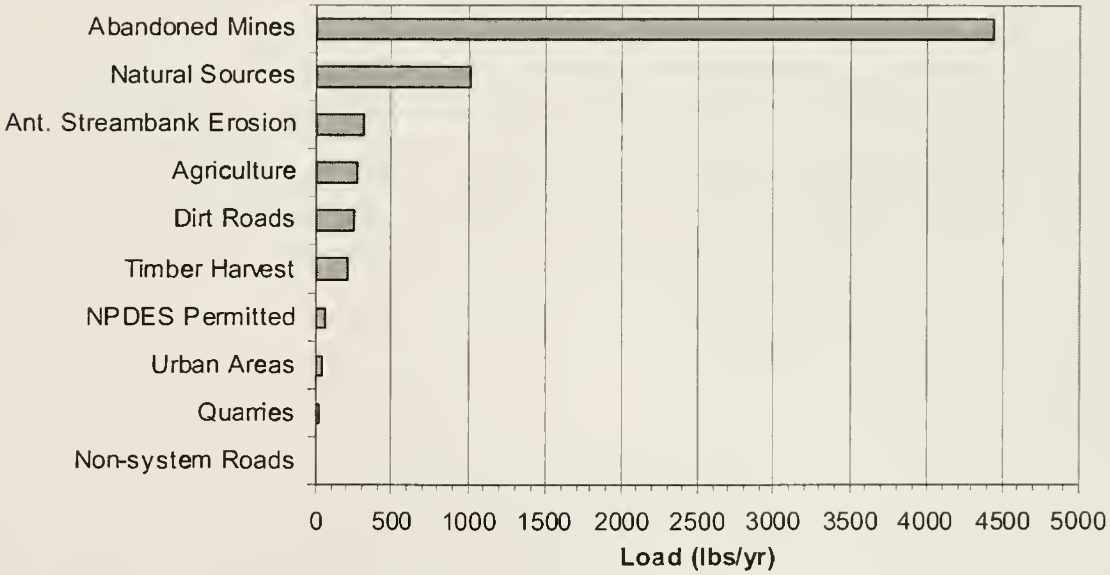

Figure 8-4. Sources of lead loadings to Prickly Pear Creek.

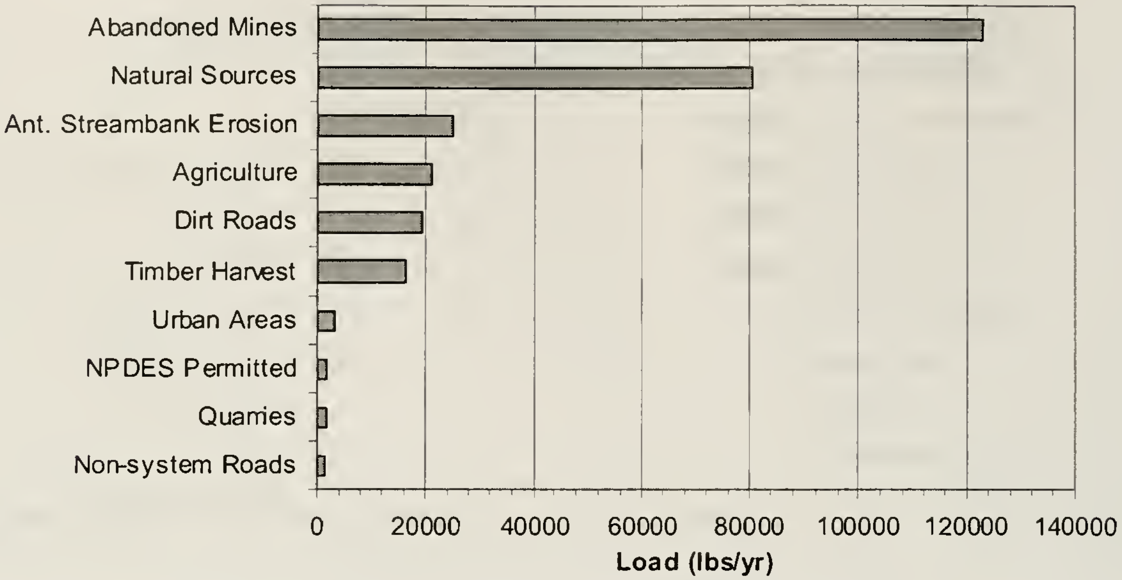

Figure 8-5. Sources of zinc loadings to Prickly Pear Creek.

8.1.2 Water Quality Goals/Targets

The ultimate goal of the metals TMDL is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in the main stem segments of Prickly Pear Creek are presented in Table 8-1.

Table 8-1. Montana numeric surface water quality standards for metals in Prickly Pear Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10[d]
Cadmium (TR)	5.2 at 235.1 mg/L hardness[c]	0.5 at 235.1 mg/L hardness[c]	5
Copper (TR)	31.0 at 235.1 mg/L hardness[c]	18.9 at 235.1 mg/L hardness[c]	1,300
Lead (TR)	238.5 at 235.1 mg/L hardness[c]	9.2 at 235.1 mg/L hardness[c]	15
Zinc (TR)	249.9 at 235.1 mg/L hardness[c]	249.9 at 235.1 mg/L hardness[c]	2,000

8.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 8-2 through Table 8-6. Based on the results of the source assessment (Section 8.1.1), the recommended implementation strategy to address the metals problem in Prickly Pear Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 8-2 through Table 8-6, the hypothesis is that an overall, watershed scale metals load reduction of 58, 74, 58, 69, and 60 percent for arsenic, cadmium, copper, lead and zinc, respectively, will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from mining sources by 67, 87, 76, 83, and 85 percent for arsenic, cadmium, copper, lead and zinc respectively.

Table 8-2. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	6,180	67.3	2,020	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data
	Agriculture	383	88	47	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	447	82	79	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	27	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	31	0	31	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	296	97	10	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	349	60	139	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	60	80	12	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	7,771	70	2,338		
	Natural Sources	1,456	0	1,458	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	271	45	149	Permitted point sources include ASARCO and Montana Tunnels. Current permit limits were applied to the permitted facility effluent. At this point in time, Montana Tunnel's permitted concentration is 290 ug/L while the criteria is 10 ug/L. Loads were reduced to the current arsenic water quality standard.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs	
Total		**9,498**	**58**	**3,943**		
TMDL	**TMDL = WLA + LA + Natural + MOS TMDL = 149+ 2,338 lbs/yr + 1,456 lbs/yr + 0 = 3,943 lbs/yr TMDL = 0.4 + 6.4 lbs/day + 4.0 lbs/day + 0 = 10.8 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 8-3. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	469	87	60	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	22	88	3	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading [1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	25	82	4	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	2	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	2	0	2	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	17	97	1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	20	60	8	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	3	80	1	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	558	86	77		
	Natural Sources	82	0	82	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled
Wasteload Allocation	**All Point Sources**	12	0	12	Permitted point sources include ASARCO and Montana Tunnels. Current permit limits were applied to the permitted facility effluent No reductions were required because permits limits already meet current water quality standards.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		652	74	171		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 12+ 77 lbs/yr + 82 lbs/yr + 0 = 171 lbs/yr** **TMDL = 0.04 + 0.21 lbs/day + 0.22 lbs/day + 0 = 0.47 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 8-4. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	6,917	76	1,668	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	896	88	110	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated
	Anthropogenic Streambank Erosion	1,046	82	185	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	63	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	72	0	72	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.[1]	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	694	97	22	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	816	60	326	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	140	80	29	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	10,644	77	2,412		
	Natural Sources	3,408	0	3,408	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled
Wasteload Allocation	**All Point Sources**	149	0	149	Permitted point sources include ASARCO and Montana Tunnels. Current permit limits were applied to the permitted facility effluent. No reductions were required because permits limits already meet current water quality standards.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		14,200	58	5,969		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 149+ 2,412 lbs/yr + 3,408 lbs/yr + 0 = 5,969 lbs/yr** **TMDL = 0.4 + 6.6 lbs/day + 9.3 lbs/day + 0 = 16.3 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 8-5. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	4,434	82	777	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data
	Agriculture	267	88	33	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	312	82	55	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	19	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	22	0	22	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	207	97	7	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	243	60	97	It is assumed that no BMPs are currently in place It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	42	80	9	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	5,545	82	999		
	Natural Sources	1,016	0	1,016	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled
Wasteload Allocation	**All Point Sources**	67	0	67	Permitted point sources include ASARCO and Montana Tunnels. Current permit limits were applied to the permitted facility effluent. No reductions were required because permits limits already meet current water quality standards.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**6,628**	**69**	**2,082**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 67+ 999 lbs/yr + 1,016 lbs/yr + 0 = 2,082 lbs/yr** **TMDL = 0.2 + 2.7 lbs/day + 2.8 lbs/day + 0 = 5.7 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 8-6. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	122,935	85	18,267	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	21,212	88	2,610	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	24,774	82	4,380	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 85%, thereby reducing sediment associated metals loads from streambank erosion by 85%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	1,482	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	1,711	0	1,711	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	16,438	97	530	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	19,330	60	7,732	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	3,324	80	679	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	211,206	83	35,909		
	Natural Sources	80,731	0	80,731	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	1,977	0	1,977	Permitted point sources include ASARCO and Montana Tunnels. Current permit limits were applied to the permitted facility effluent. No reductions were required because permits limits already meet current water quality standards.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**293,914**	**60**	**118,617**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 1,977+ 35,909 lbs/yr + 80,731 lbs/yr + 0 = 118,617 lbs/yr** **TMDL = 6 + 98 lbs/day + 221 lbs/day + 0 = 325 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

8.2 NUTRIENTS

8.2.1 Limiting Nutrients

Nitrogen and phosphorus are the two elements most commonly limiting algal growth in lakes and streams. Some indication of whether nitrogen or phosphorus is growth limiting may be obtained by determining the weight ratio of the appropriate forms of nitrogen and phosphorus found in a river or lake, and comparing that with the stoichiometric ratio required for growth. Where the ratio of nitrogen to phosphorus is greater than 15:1, phosphorus is more likely limiting than nitrogen. If the ratio is less than 5:1, nitrogen is more likely limiting than phosphorus. If the ratio is less than 15 but greater than 5, it's a tossup as to which one is limiting, i.e. either N or P could be limiting, or an N and P co-limitation could be present. For assessing nutrient limitations in streams, the N:P ratios are usually computed on the basis of the soluble inorganic forms of N and P (i.e. TSIN:SRP). For lakes, nutrient ratios are commonly computed on the basis of the total forms of N and P. This is because nutrients may cycle in lakes and become soluble over time or under certain physical and chemical conditions. Total N and total P relate better overall to seasonal and lake wide productivity.

It is important to know which nutrient is limiting such that control efforts can focus on the nutrient most likely causing the beneficial use impairments. A discussion on nutrient limitation in Prickly Pear Creek and Lake Helena, the primary receiving water body, is presented below.

8.2.1.1 Prickly Pear Creek

Nutrient data for two distinct reaches of lower Prickly Pear Creek were reviewed. It has been observed that in-stream nutrient concentrations are significantly higher below the City of Helena's municipal wastewater outfall than above the discharge, although other nutrient sources may also be present in the interim segment of the creek. It is important to examine nutrient ratios above and below these source inputs because it may influence the selection of appropriate control measures.

Soluble N to P ratios in Prickly Pear Creek at or just below East Helena documented during 2003 ranged from 1.1:1 to 5.4:1 and averaged 3.4:1, indicating that nitrogen was the limiting nutrient.

Soluble N to P ratios in Prickly Pear Creek below York Road (above Stansfield Lake) ranged from 70:1 to 85:1 during monitoring conducted in 2003. This section of the stream is dominated by groundwater discharge during the summer irrigation season and is not typical of upstream or downstream sections of Prickly Pear Creek. This section of the stream was strongly phosphorus limited.

Soluble N to P ratios in Prickly Pear Creek above Tenmile Creek (Sierra Road crossing) ranged from 2.6 to 4.6 and averaged 3.6:1 indicating a strong nitrogen limitation.

The soluble N to soluble P ratios were similar in much of Prickly Pear Creek from East Helena to above the Tenmile Creek confluence, with the exception of the dewatered, groundwater dominated segment just below York Road. Ratios were similar even though the in-stream nutrient concentrations in the reach below the City of Helena's wastewater outfall were an order of magnitude higher overall than in reach near East Helena.

8.2.1.2 Lake Helena

A review was performed of the available nitrogen and phosphorus data for Lake Helena. Four water column samples collected by the Montana Department of Environmental Quality in early August 2002 showed an average total N to total P ratio of 9.6:1, with a range from 8.5 to 10.3. Four samples collected by Land & Water Consulting in late August 2003 showed a TN:TP ratio of 2.7:1, with a range of 2.6 to 2.8. Three additional samples collected by Land & Water during runoff conditions in late June 2003 showed a TN:TP ratio of 9.3:1 with a range of 7.8 to 10.2. A fourth sample collected near the lake inlet produced a ratio of 50.5:1 due to a very low total P measurement, which may have been in error.

The Lake Helena nutrient ratio data presented above point to a conclusion that algae growth in the lake is either nitrogen limited (August 2003), or N and/or P limited (August 2002, June 2003). Based on these total nutrient ratio data, it can be concluded that the lake is not overwhelmingly phosphorus limited. Computing the N:P ratios using the soluble inorganic nutrient fractions suggests a stronger nitrogen limitation in Lake Helena, rather than a co- or P-limitation.

In the absence of a strong case for either N or P limitation, TMDLs are presented below for both nitrogen and phosphorus.

8.2.2 Nitrogen

8.2.2.1 Sources of Nitrogen in the Prickly Pear Creek Watershed

As shown in Figure 8-6, the primary anthropogenic sources of nitrogen in the Prickly Pear Creek watershed, in order of importance include municipal wastewater treatment facilities (21 percent), septic systems (20 percent), urban areas (7 percent), agriculture (7 percent), dirt roads (5 percent), anthropogenic streambank erosion (4 percent), and timber harvest (4 percent). Although dewatering does not directly contribute a nutrient load to Prickly Pear Creek, irrigation diversions reduce flows downstream of the City of East Helena significantly most summers. This result in increased in-stream nutrient concentrations and, by increasing stream temperatures (see Section 8.4), may exacerbate the symptoms of nutrient loading (e.g., algal growth and depressed dissolved oxygen levels). Also, in localized areas, nutrient loading from agricultural (predominantly grazing) and single family residential sources may be far more significant that this source category appears to be at the watershed scale.

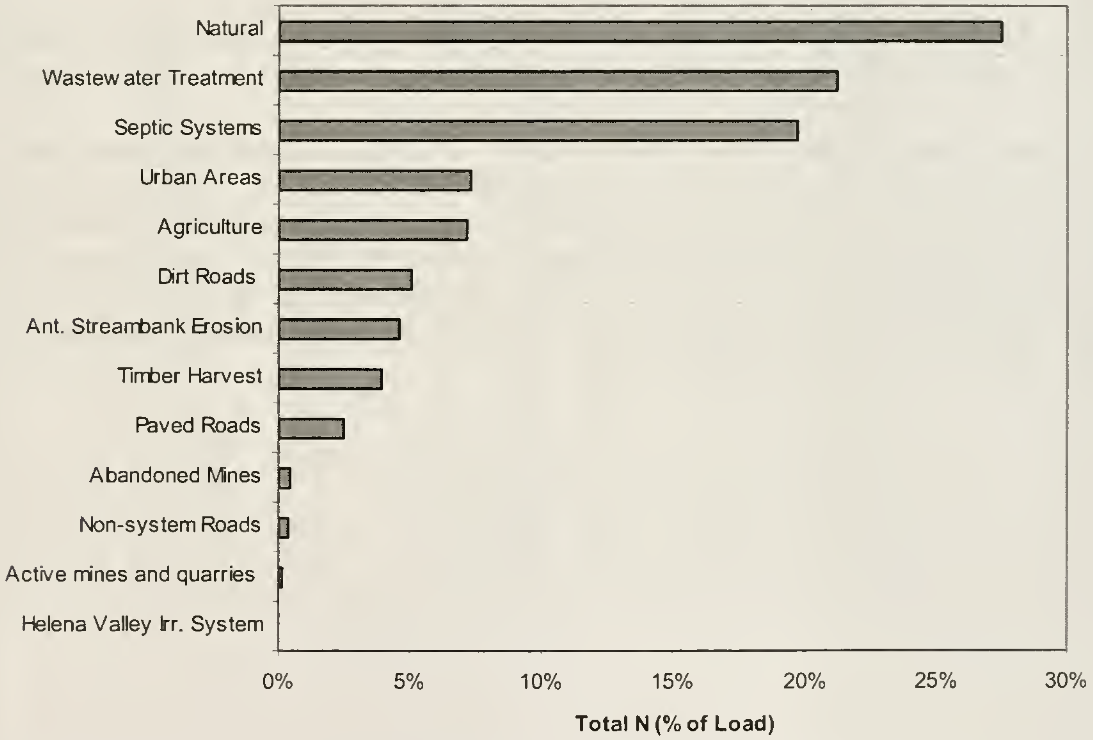

Figure 8-6. Percent of the annual TN load from all potentially significant nitrogen sources in the Prickly Pear Creek Watershed.

8.2.2.2 Water Quality Goals/Targets

The proposed interim water quality target for TN in Prickly Pear Creek is 0.33 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

8.2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the nitrogen TMDL is to attain full beneficial use support in Prickly Pear Creek. In the absence of better data/information, the interim target presented in Section 8.2.2.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 80 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, and point source loads were reduced by 90 percent, the maximum attainable nitrogen load reduction for the Prickly Pear Creek Watershed is estimated to be only 39 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Prickly Pear Creek will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TN load reductions from non-point sources, includes a phased wasteload allocation to reduce point sources loads, and, in recognition of the fact that it may not be possible to attain the TN target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 8-7 and Table 8-8. The phased wasteload allocation is presented in Appendix I and the adaptive management strategy is presented in Volume II, Section 3.0.

Table 8-7. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Nitrogen.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.9	71	0.3	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%. Sediment-associated nitrogen will decrease accordingly (71%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated nitrogen reductions could be over or under estimated.
	Active Mines	0.3	0	0.3	BMPs for active mines were assumed to not be cost effective because the loads represent such a small fraction of the current overall loads.	Current loads from active mines are based on modeled storm water runoff and literature values for runoff concentrations. The current loads are likely overestimated because DEQ reports that there has never been a discharge from the MT Tunnels Mine site (the only significant active mine in the watershed).
	Agriculture	13.3	88	1.6	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	8.5	85	1.3	It is estimated that there are 13.2 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.7	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	4.7	30	3.3	An average nitrogen removal efficiency of 30% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	37.0	0.5	36.8	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 0.5% decrease in TN. Replacing failing septic systems with level 2 treatment could result in a 1.8% reduction in TN.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	7.2	97	0.2	It is assumed that nitrogen loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, nitrogen reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	9.3	60	3.7	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding nitrogen load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	13.6	30	9.5	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average nitrogen removal efficiency of 30% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	95.5	40	57.0		
	Natural Sources	51.0	0	51.0	It is assumed that the nitrogen loads from all other source categories are natural in origin and/or negligible	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	All Point Sources	39.6	91	3.7	Nitrogen point sources are listed in Table 8-8. The allocations for the WWTPs are based on the phased approach described in Appendix I. Load reductions for known failing lagoons are presented in Table 8-8. No allocations are proposed for lagoons thought to be operating as designed.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**186.1**	**39**	**111.7**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 3.7 tons/yr + 57.0 tons/yr + 51.0 tons/yr + 0 = 111.7 tons/yr** **TMDL = 0.01 + 0.16 tons/day + 0.14 tons/day + 0 = 0.31 tons/day**					

Table 8-8. Estimated loads and load reductions for all sources of TN in the Prickly Pear Creek watershed.

Source Category	Source	Estimated TN Load (tons/yr)	Estimated Reductions (%)	Remaining Load (tons/yr)
Anthropogenic Nonpoint Sources	Abandoned Mines	0.9	71	0.3
	Active Mines	0.3	0	0.3
	Agriculture	13.3	88	1.6
	Anthropogenic Streambank Erosion	8.5	85	1.3
	Non-system Roads	0.7	100	0.0
	Paved Roads	4.7	30	3.3
	Septic Systems	37.0	0.5	36.8
	Timber Harvest	7.2	97	0.2
	Unpaved Roads	9.3	60	3.7
	Urban Areas	13.6	30	9.5
	Total Anthropogenic NPS Load	**95.5**	40	**57.0**
Natural Nonpoint Sources	Fullgrowth Forest	9.3	0	9.3
	Wetlands	0.1	0	0.1
	Shrubland	3.0	0	3.0
	Grassland	23.9	0	23.9
	Nat. Streambank Erosion	1.6	0	1.6
	Groundwater	13.1	0	13.1
	Total Natural NPS Load	**51.0**	**0**	**51.0**
Anthropogenic Point Sources	City of Helena	31.8	92	2.5
	East Helena	6.5	97	0.2
	Evergreen Nursing Home	0.1	0	0.1
	Treasure State Acres subdivision	0.1	50	0.0
	Tenmile and Pleasant Valley subdivisions	0.8	21	0.6
	Mountain View law enforcement academy	0.2	0	0.2
	Eastgate Subdivision	0.1	0	0.1
	Total Point Source	**39.6**	91	**3.7**
Total	**Totals**	**186.1**	39	**111.7**

8.2.3 Phosphorus

8.2.3.1 Sources of Phosphorus in the Prickly Pear Creek Watershed

As shown in Figure 8-7, the primary anthropogenic sources of phosphorus in the Prickly Pear Creek watershed, in order of importance, are municipal wastewater treatment (42%), agriculture (8%), dirt roads (6%), anthropogenic streambank erosion (5%), timber harvest (4%) and urban areas (4%). As with nitrogen, dewatering may also be a complicating factor for phosphorus and, in localized areas, phosphorus loading from agricultural (predominantly grazing) and single family residential sources may be far more significant that this source category appears to be at the watershed scale.

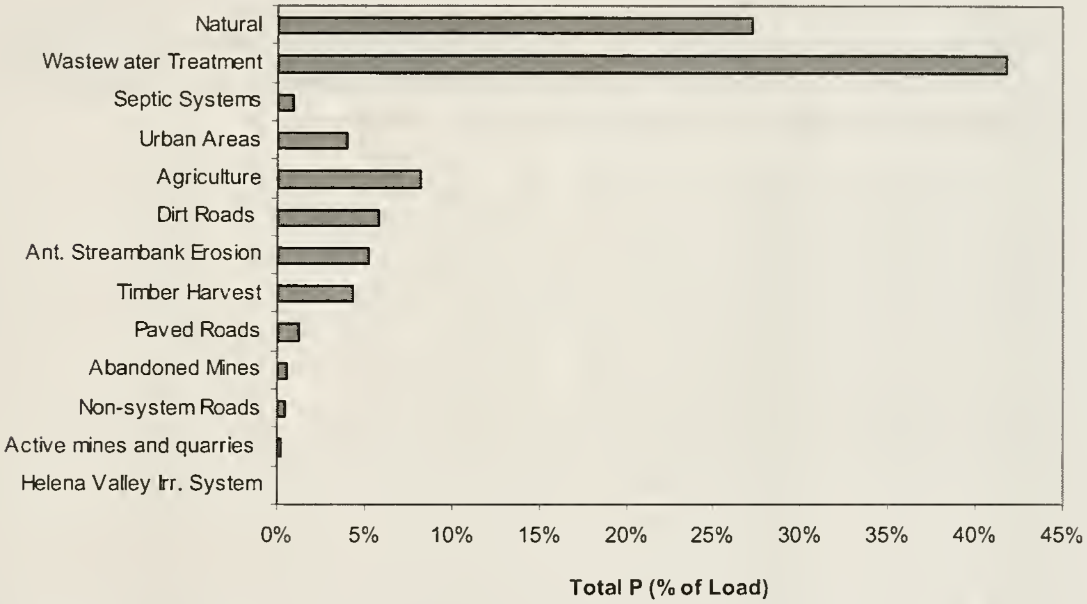

Figure 8-7. Percent of the annual TP load from all potentially significant phosphorus sources in the Spring Creek Watershed.

8.2.3.2 Water Quality Goals/Targets

The proposed interim water quality target for TP in Prickly Pear Creek is 0.04 mg/L (See Volume I Section 3.2.3). A strategy to revise this target, if deemed appropriate, is presented in Volume I, Section 3.2.3.

8.2.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the phosphorus TMDL is to attain full beneficial use support in Prickly Pear Creek. In the absence of better data/information, the interim target presented in Section 1.1.2.2 is assumed to represent the phosphorus level below which all beneficial uses would be supported. A phosphorus load reduction of 87 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, and point source loads were reduced by 98 percent, the maximum attainable phosphorus load reduction for the Prickly Pear Creek Watershed is estimated to be only 62 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Prickly Pear Creek will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable phosphorus load reductions from non-point sources, includes a phased wasteload allocation to reduce point sources loads, and, in recognition of the fact that it may not be possible to attain the phosphorus target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 8-9 and Table 8-10. The phased wasteload allocation is presented in Appendix I and the adaptive management strategy is presented in Volume II, Section 3.0.

Table 8-9. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek –Phosphorus.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.2	71	0.1	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%. Sediment-associated phosphorus will decrease accordingly (71%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated nitrogen reductions could be over or under estimated.
	Active Mines	0.1	0	0.1	BMPs for active mines were assumed to not be cost effective because the loads represent such a small fraction of the current overall loads.	Current loads from active mines are based on modeled storm water runoff and literature values for runoff concentrations. The current loads are likely overestimated because DEQ reports that there has never been a discharge from the MT Tunnels Mine site (the only significant active mine in the watershed)
	Agriculture	2.9	90	0.3	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	1.9	90	0.2	It is estimated that there are 13 2 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate
	Non-system Roads	0.2	100	0	Ideally all non-system roads should be closed and reclaimed	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	0.5	50	0.3	An average phosphorus removal efficiency of 50% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations The current loads may be over or underestimated.
	Septic Systems	0.3	100	0.0	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 100% decrease in TP.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated
	Timber Harvest	1.6	97	0	It is assumed that phosphorus loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, phosphorus reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	2.1	60	0.8	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding phosphorus load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.4	50	0.7	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average phosphorus removal efficiency of 50% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	11.0	78	2.4		
	Natural Sources	9.6	0	9.6	It is assumed that the phosphorus loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	All Point Sourcee	14.9	89	1.6	Phosphorus point sources are listed in Table 8-10. The allocations for the WWTPs are based on the phased approach described in Appendix I. Load reductions for known failing lagoons are presented in Table 8-10. No allocations are proposed for lagoons thought to be operating as designed	Actual discharge quantity and quality will likely be below that assumed These loads are likely over-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		35.5	62	13.6		
TMDL	TMDL = WLA + LA + Natural + MOS TMDL = 1.6 tons/yr + 2.4 tons/yr + 9.6 tons/yr + 0 = 13.6 tons/yr TMDL = 0.001 tons/day + 0.006 tons/day + 0.026 tons/day + 0 = 0.033 tons/day					

Table 8-10. Estimated loads and load reductions for all sources of TP in the Prickly Pear Creek watershed.

Source Category	Source	Estimated TP Load (tons/yr)	Estimated Reductions (%)	Remaining Load (tons/yr)
Anthropogenic Nonpoint Sources	Abandoned Mines	0.2	71	0.1
	Active Mines	0.1	0	0.1
	Agriculture	2.9	90	0.3
	Anthropogenic Streambank Erosion	1.9	90	0.2
	Non-system Roads	0.2	100	0
	Paved Roads	0.5	50	0.3
	Septic Systems	0.3	100	0
	Timber Harvest	1.6	97	0
	Unpaved Roads	2.1	60	0.8
	Urban Areas	1.4	50	0.7
	Total Anthropogenic NPS	**11.0**	**78**	**2.4**
Natural Nonpoint Sources	Fullgrowth Forest	2.0	0	2.0
	Wetlands	0.02	0	0.02
	Shrubland	0.6	0	0.6
	Grassland	5.2	0	5.2
	Nat. Streambank Erosion	0.4	0	0.4
	Groundwater	1.4	0	1.4
	Total Natural NPS	**9.6**	**0**	**9.6**
Anthropogenic Point Sources	City of Helena	13.5	98	0.3
	East Helena	1.0	0	1.0
	Evergreen Nursing Home	0	0	0
	Treasure State Acres subdivision	0.1	33	0.1
	Tenmile and Pleasant Valley subdivisions	0.1	14	0.1
	Mountain View law enforcement academy	0.1	0	0.1
	Eastgate Subdivision	0.1	0	0.1
	Total Point Source	**14.9**	**89**	**1.6**
Total		**35.5**	**62**	**13.6**

8.3 SEDIMENT

Based on the results summarized in Volume I, Prickly Pear Creek is impaired due to excessive levels of sediment from the headwaters downstream to Lake Helena. The following sediment TMDL addresses all five water quality limited segments described in Section 1.0.

8.3.1 Sources of Sediment in the Prickly Pear Creek Watershed

As shown in Figure 8-8 the primary anthropogenic sources of sediment in the Prickly Pear Creek watershed, in order of sediment load are agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads, abandoned mines, and active mines and quarries. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that they are adequate for making relative comparisons, they should not be used directly as quantity estimates.

Agriculture was the single greatest sediment source within the greater Prickly Pear Creek watershed, representing 32 percent of the total anthropogenic sediment load. As a land-use, agriculture occurs in the lower elevation areas of the watershed including middle and lower Tenmile, Sevenmile and Prickly Pear Creek watersheds. On a segment scale, two central Prickly Pear segments, Lump Gulch to Wylie Drive (MT41I006_040), and Wylie Drive to Helena Wastewater Treatment Plant Discharge (MT41I006_030), produced the greatest quantities of agriculture related sediment in the entire Prickly Pear watershed; 2,792 and 1,284 tons respectively. Unpaved roads were the second greatest anthropogenic sediment source, accounting for 23 percent of this load. Prickly Pear Creek from Lump Gulch to Wylie Drive (MT41I006_040) was the segment that produced the greatest quantity of road related sediment, 701 tons. This load is generated from high road densities related to sub-division development throughout this segment. Segments within the greater Prickly Pear Creek watershed that generate the largest streambank erosion sediment loads include Clancy Creek, Sevenmile Creek, and Prickly Pear above Lake Helena watersheds, respectively. Causes of streambank erosion in these watersheds are riparian grazing, road encroachment, stream channelization, riparian vegetation removal, and historic mining activity.

Watersheds that produced the greatest quantity of sediment related to timber harvest were Lump Gulch, Prickly Pear Creek above Wylie Drive, upper Tenmile Creek, and Clancy Creek, respectively. All of which produced more than 300 tons of sediment per year from silviculture activities. Sediment from urban areas is related to developed areas in the lower watersheds throughout the Helena Valley and the central Prickly Pear drainage. Non-system roads/trails occur throughout the entire watershed. Densities of these roads/trails are typically greater on public lands of the upper areas of the watershed. A total of thirty abandoned mines were identified to be capable of delivering sediment to perennial stream channels throughout the greater Prickly Pear Creek watershed. Five of these mines – Alta, Bertha, Corbin Flats, Gregory, and Nellie Grant – have been reclaimed by Montana DEQ. All of the mines are located in the upper tributary watersheds. Sediment from active mines and quarries is generated in lower Tenmile and Prickly Pear watersheds and is related to gravel pit operations and the like. Additionally, the Helena Wastewater Treatment Plant, the largest suspended sediment discharger in the watershed, generates a total suspended sediment load from of 54 tons per year. The meager size of this source relative to the previously described source categories warrants minimal concern or attention.

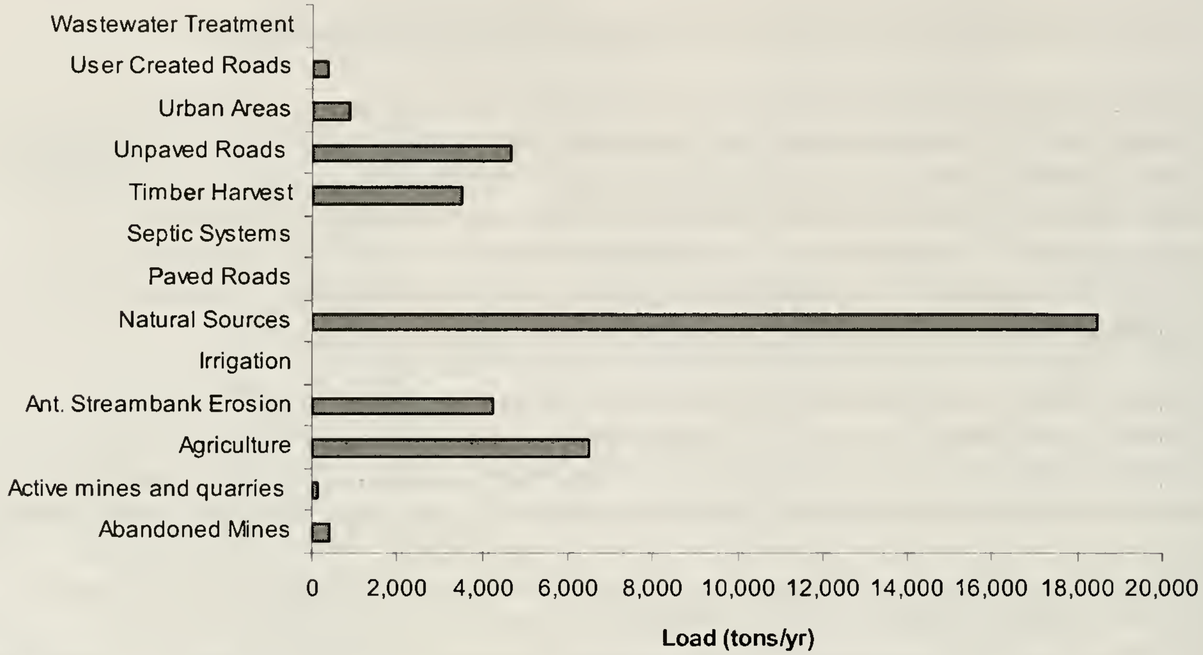

Figure 8-8. Total annual sediment load from all potentially significant sediment sources in the Prickly Pear Creek Watershed.

8.3.2 Water Quality Goals/Targets

The ultimate goal of this sediment TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.3.3.

8.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 8-11. The TMDL is presented at the scale of the entire Prickly Pear Creek watershed. Note that individual sediment TMDLs have also been prepared for the following tributaries: Clancy Creek (MT41I006_120), Corbin Creek (MT41I006_090), Golconda Creek (MT41I006_070), Jackson Creek (MT41I006_190), Sevenmile Creek (MT41I006_160), Jennie's Fork (MT41I006_210), Skelly Gulch (MT41I006_220), Lump Gulch (MT41I006_130), Spring Creek (MT41I006_080), Middle Fork Warm Springs Creek (MT41I006_100), Tenmile Creek (MT41I006_141), North Fork Warm Springs Creek (MT41I006_180), Tenmile Creek (MT41I006_142), Tenmile Creek (MT41I006_143), and Warm Springs Creek (MT41I006_110). TMDLs for the individual tributaries are presented in Appendix A.

Based on the results of the source assessment (Section 8.3.1), the recommended implementation strategy to address the siltation problem in Prickly Pear Creek is to reduce sediment loading from the primary anthropogenic sediment sources – agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads, abandoned mines, and active mines and quarries. As shown in Table 8-11, the hypothesis is that an overall, watershed scale sediment load reduction of 38 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads, and abandoned mines by 60, 60, 85, 97, 80, 100, and 79 percent, respectively.

Table 8-11. TMDL, Allocations, and Margin of Safety for Prickly Pear Creek – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	424	71	123	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 71%.	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
	Agriculture	6,526	60	2,610	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing erosion.	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	4,244	85	637	It is estimated that there are 13.2 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	367	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	144	0	144	Loading estimates reflect no reduction in load allocation. This is due to the small load size relative to other sediment sources.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	3,493	97	105	It is assumed that sediment loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	4,655	60	1,862	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	855	80	171	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	20,708	73	5,652		
	Natural Sources	18,480	0	18,480	It is assumed that the sediment loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	54	0	54	Sediment Point Sources: City of Helena WWTP. This load is considered insignificant, and therefore no wasteload reduction is required.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		39,242	38	24,186		
TMDL	**TMDL = WLA + LA + Natural + MOS TMDL = 54+ 5,652 tons/yr + 18,480 tons/yr + 0 = 24,186 tons/yr TMDL = 0.1 + 15.5 tons/day + 50.7 tons/day + 0 = 66.3 tons/day**					

8.4 TEMPERATURE

Measured in-stream temperatures, riparian assessments, and modeling all suggest that Prickly Pear Creek (from where to where including what segments) is impaired by temperature (see Volume I Report). TMDLs are presented in the following sections to address the temperature impairment in Prickly Pear Creek.

8.4.1 Sources of Temperature Impairment in the Prickly Pear Creek Watershed

Sources of temperature impairment were identified through field assessments, aerial surveys, and MPDES data. There are three key sources of thermal modifications in the watershed – flow alterations, riparian degradation, and point sources. The following sections summarize each source of impairment. More detailed descriptions are included in Appendix G.

8.4.1.1 Flow Alterations

Flow alterations indirectly impact stream temperature because of simple energy mechanics. When there is less water in the stream, the water is easier to heat. Flow alterations exist throughout Prickly Pear Creek in the form of irrigation withdrawals, industrial withdrawals, and dams. These flow alterations are pervasive throughout the lower six miles of the stream due to intense agriculture and industry near the Helena Valley. Figure 8-9 shows the major diversions and dams identified during the Prickly Pear Creek source assessment. Four major diversions were identified on Prickly Pear Creek between the confluence with Lump Gulch and Lake Helena. During the field assessment, it was noted that flows were almost entirely diverted out of Prickly Pear Creek, with almost no flow occurring in the segment between the Wylie Drive Bridge and the confluence with the Helena WWTP outfall. Montana Fish, Wildlife, and Parks considers this segment "chronically dewatered" during most years (MFWP, 2005).

Synoptic flow measurements, USGS gaging station records, and the DNRC water rights database were used to construct recent summer flows and diversions along Prickly Pear Creek from Lump Gulch to Lake Helena. The creek was divided into five segments to create a simple summer (i.e., critical conditions) flow budget based on data measured on or estimated for August 7, 2003. The modeling segments are described in Table 8-12, and Table 8-13 describes the flow budget for August 7, 2003.

The flow budget was then input into a stream temperature model (SSTEMP) to predict the impact of flow diversions on stream temperatures. Details for the SSTEMP modeling, as well as the flow budget, are included in Appendix G.

The SSTEMP model predicted that flow alterations in Segments 1, 2, and 3 cumulatively raise the stream temperature by 1.8 degrees Fahrenheit during critical low flow summer months. The impact of any flow alterations located downstream of Segment 3 could not be evaluated because Prickly Pear Creek – during summer low flows – is not hydrologically connected due to dewatering.

Table 8-12. Temperature impaired segments of Prickly Pear Creek and the corresponding SSTEMP modeling segments.

303(d) Segment	Modeling Segment	Location
MT41I006_040	Segment 1a	Confluence with Lump Gulch to USGS gage #06061500 (3.5 miles).
	Segment 1b	Confluence with Lump Gulch to confluence with McClellan Creek (6.8 miles).
	Segment 2	Confluence with McClellan Creek to ASARCO Dam (1.7 miles).
	Segment 3	ASARCO Dam to Wylie Drive (1.7 miles).
MT41I006_030	Segment 4	Wylie Drive to Helena Wastewater Treatment Plant discharge (4.3 miles)
MT41I006_020	Segment 5a	Helena Wastewater Treatment Plant to Sierra Road (2.7 miles).
	Segment 5b	Helena Wastewater Treatment Plan to the mouth (5.9 miles).

Table 8-13. Summary of major summer inflows and outflows along lower Prickly Pear Creek.

303(d) Segment	Modeling Segment	Flow Gains (cfs)	Flow Losses (cfs)	Flow Budget (cfs)	Flow Sources/ Withdrawals
MT41I006_040	1	1.4	None	+1.4	Tributary Inflow and Groundwater Discharge
	2	9.9	9.9	0.0	Tributary Inflow *(Irrigation Diversions)*
	3	None	6.0	-6.0	*(Irrigation Diversions)*
MT41I006_030	4*	1.5	3.0	-1.5	Groundwater Discharge *(Irrigation Diversions)*
MT41I006_020	5	15.0	None	+15.0	Groundwater Discharge and Irrigation Return

* Segment 4 is totally dewatered, but flow gains from groundwater discharge occur near the end of the reach. Therefore, flows between Segments 3, 4,and 5 are not hydrologically connected.

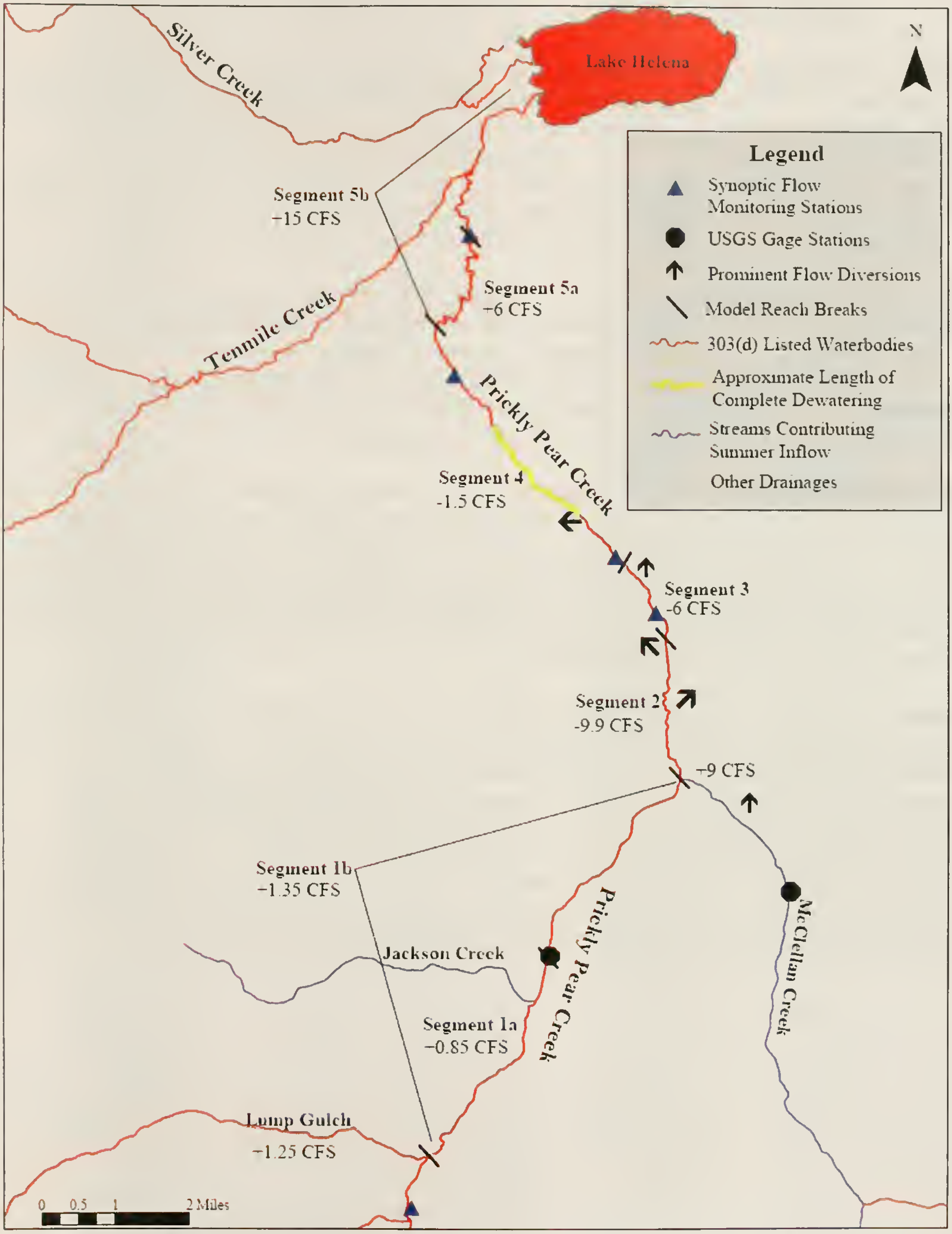

Figure 8-9. General overview of major summer inflows and outflows along lower Prickly Pear Creek.

8.4.1.2 Riparian Degradation

Among other things, Stream temperature is a function of riparian vegetation – more riparian vegetation generally translates into more stream shade, and lower stream temperatures. Riparian data from numerous sources were evaluated to assess the riparian condition of Prickly Pear Creek. Proper Functioning Condition (PFC) assessments were conducted at three sites along lower Prickly Pear Creek in 2003 (see Figure 8-9). The most upstream site ranked as functional, but at risk. Segments 4 and 5 (downstream most segments) ranked as non-functional, indicating severe riparian degradation along these segments.

Quantitative riparian vegetation data were obtained for the SSTEMP stream temperature model. Data were collected at 11 sites in 2005 and included topographic altitude (degrees), distance to vegetation, angle to vegetation top (degrees), vegetation height (ft), vegetation type, vegetation crown (ft), vegetation offset (ft), and vegetation density (%). The measured existing data are summarized in Figure 8-10, and assessment locations are shown in Figure 8-9. Detailed information about the riparian survey is included in Appendix G.

Natural riparian conditions (i.e., the maximum potential riparian vegetation) were estimated based on the measured data, comparable reference streams, and best professional judgment. Figure 8-11 summarizes theoretical maximum potential riparian measurements for the riparian field inventory sites along lower Prickly Pear Creek. Comparing the maximum potential and existing riparian conditions, it appears that current riparian vegetation is located farther from the stream, with vegetation having less height and density. Also, there is a lack of mature cottonwood trees in the current riparian area.

Both the natural and existing riparian conditions were input into the SSTEMP stream temperature model (see Appendix G). Existing and natural conditions were compared to quantify the effect of riparian degradation on stream temperature during a critical low flow summer event (as measured on August 7, 2003). The SSTEMP model predicted that the cumulative impact of riparian degradation to existing stream temperatures is 0.90 degrees Fahrenheit. This is the cumulative impact of riparian degradation through Segment 3 (Lump Gulch to the Wylie Drive Bridge). The impact of any flow alterations located downstream of Segment 3 could not be evaluated because Prickly Pear Creek – during summer low flows – is not hydrologically connected because of dewatering (see Section 8.4.1.1).

Figure 8-10. Summary of the existing riparian conditions for Prickly Pear Creek.

Sample Location ID[1]	Topographic Altitude (degrees)		Vegetation Height (ft)		Vegetation Type		Vegetation Crown (ft)		Vegetation Offset (ft)		Vegetation Density (%)	
	East	West	East	West	East	West	East	West	East	West	East	West
Segment 1-1	8	4	24	0	willow/alder	grass	8	0	1	0	85	7
Segment 1-2	22	7	24	14	willow/alder	willow/alder	18	23	1	2	40	60
Segment 1-3	5	4	28	27	willow/alder	willow/alder	20	12	2	5	70	85
Segment 3 -1	7	27	17	0	willow some alder	grass	5	0	8	0	90	0
Segment 3 -2	4	6	34	52	cottonwood/willow	cottonwood/willow	15	15	0.5	4	70	45
Segment 4 -1	3	10	12	45	willow/alder	cottonwood/willow	7	27	4	2	20	90
Segment 4 -2	10	2	0	5	Grass	sparse willows	0	6	0	1	0	1
Segment 4 -3	5	5	11	0	Willow	grass	14	0	30	0	20	0
Segment 5 -1	9	2	0	0	Grass	grass	0	0	0	0	0	0
Segment 5 -2	1	5	8	6	Willow	willow	18	30	55	55	20	40
Segment 5 -3	7	5	10	0	Willow	grass	5	0	5	0	90	0

[1] Number references refer to upstream to downstream inventory locations. Refer to Table 8-14 for actual locations.

Figure 8-11. Summary of theorized maximum potential riparian conditions for Prickly Pear Creek.

Sample Location ID	Topographic Altitude (degrees)		Vegetation Height (ft)		Vegetation Type		Vegetation Crown (ft)		Vegetation Offset (ft)		Vegetation Density (%)	
	East	West	East	West	East	West	East	West	East	West	East	West
Segment 1	10	12	25	15	willow/alder	willow/alder	10	15	2	1	60	65
Segment 2	10	12	15	15	willow/alder	willow/cottonwood	10	15	3	2	50	55
Segment 3	10	13	20	10	willow/cottonwood	willow/alder	15	10	2	2	60	50
Segment 4	10	15	10	15	willow/cottonwood	willow/cottonwood	15	15	2	2	65	55
Segment 5	10	10	15	25	willow/cottonwood	cottonwood/willow	15	30	2	5	55	50

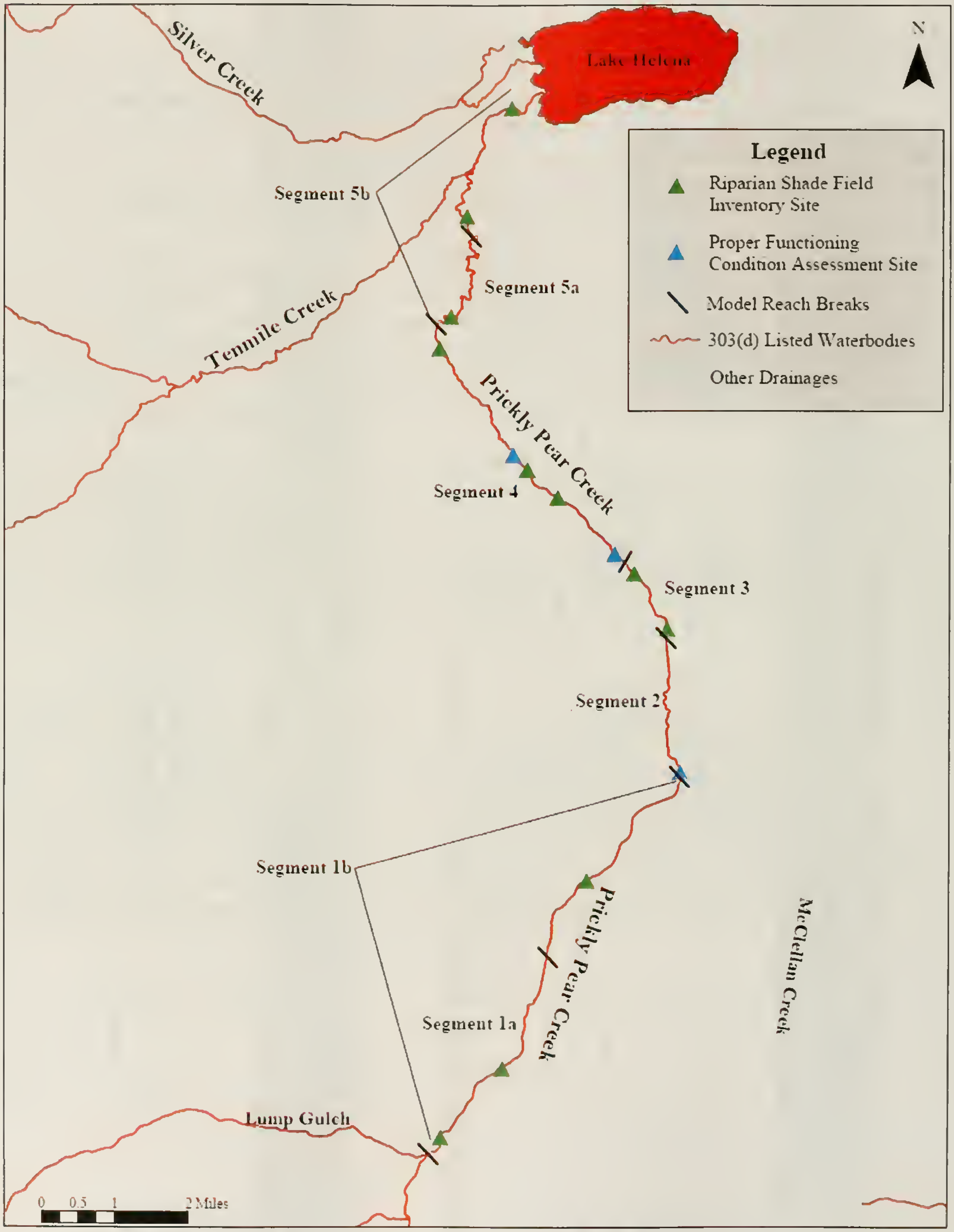

Table 8-14. Riparian field evaluation sites along lower Prickly Pear Creek.

8.4.1.3 Point Sources

There are five entities with MPDES permits along lower Prickly Pear Creek – Ash Grove Cement Company (MT0000451), Air Liquide America Corporation (MT0000426), ASARCO (MT0030147), City of East Helena WWTP (MT0022560), and City of Helena WWTP (MT0000949). An analysis of discharge and temperature data suggests that Ash Grove Cement Company, Air Liquide America Corporation, and ASARCO are having negligible impacts to temperature in Prickly Pear Creek. This is mostly due to the fact that these three facilities rarely (if ever) discharge to surface water. The City of East Helena and City of Helena WWTP outfalls may be having larger impacts to stream temperature. They contribute an average of 3.1 and 0.20 MGD, respectively, and the Helena WWTP effluent potentially constitutes the majority of flow in Segment 5 during summer months. However, neither facility monitors effluent temperature. Therefore, potential impacts from these facilities could not be evaluated at this time. Additional effluent monitoring for both facilities is proposed (see the Sampling and Analysis Plan in Appendix H), and the temperature TMDLs may have to be revised when the new monitoring data are assessed.

8.4.1.4 Summary of Sources

Stream temperature is a function of many parameters such as air temperature, humidity, cloud cover, riparian vegetation, point sources, and stream flow or volume. Of these, riparian vegetation, flow, and point sources are the sources that can be directly influenced and controlled by human activity. As shown in Sections 8.4.1.1 and 8.4.1.2, flow alterations and riparian degradation are increasing stream temperatures in Prickly Pear Creek. Point sources are having minimal impact. The cumulative effect of all three sources is presented below in Table 8-15. Combined, stream temperature in Prickly Pear Creek through Segment 3 is 2.7 ± 0.5 degrees Fahrenheit greater than the natural stream temperature. The cumulative impact of stream temperature from Lump Gulch to the mouth (Segments 1 through 5) could not be evaluated because the stream is completely dewatered in Segment 4, and therefore Prickly Pear Creek is not hydrologically connected from the upstream to the downstream segments. Detailed information about SSTEMP and the modeling assumptions can be found in Appendix G.

Table 8-15. Sources and amount of thermal modifications in Prickly Pear Creek.

303(d) Segment	Modeling Segment[1]	Riparian Vegetation	Flow Alterations	Point Sources	Total Thermal Modification
MT41I006_040	1	0.0 °F	0.0 °F	None	0.0 °F
	2	0.6 °F	1.0 °F	Insignificant	1.6 °F ± 0.5 °F
	3	0.9 °F	1.8 °F	None	2.7 °F ± 0.5 °F
MT41I006_030	4[2]	NA	NA	NA	NA
MT41I006_020	5[3]	2.1 °F	None	None	0.5 °F ± 1.2 °F

[1] Thermal modifications presented here are cumulative from Lump Gulch through the end of the evaluated modeling segment.
[2] Reaches 4 is dewatered and could not be evaluated with the SSTEMP model.
[3] Reach 5 consists of groundwater recharge and irrigation returns, and flows are not hydrologically connected to upstream segments during critical low flow summer months.

8.5 WATER QUALITY GOALS/TARGETS

The ultimate goal of this plan and associated TMDLs is to attain and maintain water quality standards. Montana's water quality standards for temperature are numeric. However, the definition of 'naturally occurring' water temperature within the state standard must be interpreted to derive measurable water quality goals.

Since the success of this plan and associated TMDLs will be formally evaluated five years after it is approved (i.e., 2011 assuming approval in 2006), flexibility must be provided herein for the interpretation of 'naturally occurring' water temperature in Prickly Pear Creek. The water quality standards and indicators presented in Table 8-16 are proposed as end-point water quality goals (i.e., targets) for temperature, in recognition of the fact that they may need to be changed in the future as new information becomes available and/or DEQ implements a new methodology for interpreting 'naturally occurring' water temperature.

The suite of indicators used to evaluate compliance with Montana's temperature standards in the future should be selected based on the best data and information available, and/or the current DEQ methodology available, at that time.

Table 8-16. Proposed Temperature Water Quality Endpoints.

<table>
<tr><th>Water Quality Indicator</th><th colspan="2">State Water Quality Standard</th></tr>
<tr><td>Water Temperature: A change in temperature due to anthropogenic sources, or variation from a reference condition.</td><td colspan="2">B-1 Class Waters: ≤ 1° F when water temperature is < 67 ° F
≤ 0.5° F when water temperature is > 67 ° F
I Class Waters: No increase in naturally occurring water temperature.</td></tr>
<tr><th>Water Quality Indicator</th><th>Rationale for Selection of this Indicator</th><th>Proposed Criteria</th></tr>
<tr><td>Percent Shade</td><td>Shading provided by riparian vegetation is a significant factor for reducing thermal energy input to Prickly Pear Creek. Riparian vegetation can also influence channel form and the amount of surface area exposed to solar heating.</td><td>60 Percent</td></tr>
<tr><td>Fish Population Metrics</td><td>The presence of cold-water fish can be an indication of the temperature suitability of a stream, when the waterbody is not limited by other water quality or habitat constraints.</td><td>MFISH rating of "best" or "substantial"</td></tr>
<tr><td>Stream Flow</td><td>Because water has a high specific heat capacity, larger volumes of water are subject to fewer fluctuations in temperature. By increasing flow, the stream will be more resistant to temperature increases.</td><td>Maintain MFWP's recommended year round aquatic life survival flow targets: 8 to 22 cfs for Prickly Pear Creek from the headwaters to East Helena, 14 to 30 cfs from East Helena to Lake Helena.</td></tr>
</table>

8.6 TOTAL MAXIMUM DAILY LOAD, ALLOCATIONS, AND MARGIN OF SAFETY

8.6.1 Prickly Pear Creek from Lump Gulch to the Wylie Drive Bridge

The goal of the temperature TMDL is to attain full beneficial use support in Prickly Pear Creek. The TMDLs presented here are based on an average, drought, summer low flow condition, which is considered the critical condition for evaluating temperature impairment. Based on the SSTEMP modeling analysis, the natural average daily temperature at the end of Segment 3 (Wylie Drive Bridge) is 66.5 degrees Fahrenheit. Montana's numeric temperature standards allow for a one degree Fahrenheit increase from the natural stream temperature. Therefore, the temperature target for Prickly Pear Creek at the Wylie Drive Bridge is 67.5 degrees. A 0.5 degree margin of safety was then applied to account for the reported uncertainties in the SSTEMP model (95 percent confidence interval), making the target temperature 67.0 degrees Fahrenheit.

The SSTEMP model and measured data reported that the existing average stream temperature at the Wylie Drive Bridge is 69.2 degrees Fahrenheit. This is a result of riparian degradation (0.9 °F), flow alterations (1.8 °F), and natural background temperature (66.5 °F). Therefore, a 2.2-degree reduction in stream temperature is needed to achieve the temperature target of 67.0 degrees Fahrenheit.

Recognizing that flow and riparian vegetation are correlated, the necessary temperature reduction can be achieved through several possible scenarios where flow in the creek is augmented (i.e., less flow alterations) and/or riparian vegetation is restored. Table 8-17 summarizes the most feasible scenario for Prickly Pear Creek (Lump Gulch to the Wylie Drive Bridge), where riparian vegetation is restored to the maximum potential along the entire 10.2 mile reach of Prickly Pear Creek, and flows are augmented by a minimum amount (8.5 cubic feet per second) to achieve the necessary temperature reduction of 2.2 degrees Fahrenheit. Again, this is simply one scenario in which it is possible to achieve the target.

It is recognized here that neither Montana DEQ nor USEPA has authority to regulate non-point sources (i.e., riparian vegetation or flow). Therefore, implementation of this TMDL will be voluntary, with watershed stakeholders ultimately deciding the restoration strategy.

Table 8-17. Temperature TMDL for Prickly Pear Creek from Lump Gulch to Wylie Drive.

Allocation	Thermal Source	Current Temperature	Temperature Reduction	Allowable Temperature	Rationale/Assumptions
Load Allocation	Riparian Degradation	0.9 °F	100%	0.0 °F	Ideally, all riparian vegetation should be restored to the maximum potential to increase shading by an average of 40%
	Flow Alteration	1.8 °F	72%	0.5 °F	Ideally, stream flows should meet minimum requirements set forth by MFWP. However, for the purpose of this TMDL scenario, flows were augmented by 8.5 cfs to achieve the temperature reduction of 2.2 °F
	Total – All Anthropogenic Nonpoint Sources	2.7 °F	81%	0.5 °F	
	Natural Background	66.5 °F	None	66.5 °F	Background conditions were modeled as having the maximum potential riparian vegetation, and no flow diversions, for a critical low flow summer time period.
Waste Load Allocation	All Point Sources	0.0 °F	None	0.0 °F	Point source loads are minimal when compared to riparian vegetation and flow alterations. Additional monitoring is needed to quantify the effect of the Helena and East Helena WWTP outfalls.
Margin of Safety		NA	0.0	0.5 °F	The 95% confidence interval for the SSTEMP model was ± 0.5 °F. This amount was subtracted from the calculated allowable temperature (67.5 °F) to derive the temperature target of 67.0 °F.
Total		**69.2 °F**	**2.2 °F**	**67.0 °F**	The *Allowable Temperature* is the natural temp (66.5 °F) + 1 °F, and minus 0.5 °F to account for the margin of safety.

[1] Values presented in the Table are average daily stream temperatures for a critical summer low flow time period.

8.6.2 Prickly Pear Creek from the Wylie Drive Bridge to the Mouth

Prickly Pear Creek from the Wylie Drive Bridge to Lake Helena (modeling segments 4 and 5) presents a unique challenge for temperature allocations. Prickly Pear Creek from Wylie Drive to the Helena WWTP outfall (Segment 4) has a section that is completely dewatered. According to model results, temperatures within the dewatered segment may be 5.4 degrees F greater than average natural temperatures. However modeling results are unreliable because the segment could not be properly calibrated.

The segment of Prickly Pear Creek downstream of the completely dewatered reach (Segment 5) presents a challenge due to the hydrologic disconnection of surface water. Water in this segment mostly consists of groundwater recharge and irrigation returns, and cumulative thermal modifications from upstream do not currently carry over into Segment 5 during critical low flow summer periods. Therefore, when analyzed as a single segment, Prickly Pear Creek from the Helena WWTP outfall to the mouth is not exceeding the numeric temperature water quality standard for a B-1 stream. The daily average existing temperature during critical conditions is only 0.5 degrees F greater than the average natural temperature during the same time period.

Although thermal allocations are not quantifiable at this time, Prickly Pear Creek from the Wylie Drive Bridge to Lake Helena is still considered impaired because of thermal modifications. First, riparian areas were in poor condition along this section of the creek (see Section 8.4.1.2). This condition exceeds the target defined in Section 8.5 – i.e., no significant disturbance of riparian vegetation. Second, this segment does not achieve the flow target selected by MFWP – i.e., maintain a flow of ranging from 14 to 30 cfs throughout the lower segments of Prickly Pear Creek. And third, if this segment was hydrologically connected to the upstream segments of Prickly Pear Creek, the thermal impairments from upstream would most likely carry through to the mouth, and this segment would be impaired. Voluntary efforts to improve the riparian condition and in-stream flows along this portion of the stream should be pursued in an attempt to bring the stream in compliance with the temperature water quality targets, and with Montana Fish, Wildlife, and Parks flow recommendations. Because of the dewatering, Prickly Pear Creek from the Wylie Drive Bridge to the Helena WWTP outfall is also considered impaired because of flow alterations. Aquatic life and fishery beneficial uses are impaired. No flow TMDLs will be presented at this time.

9.0 SEVENMILE CREEK

Sevenmile Creek from the headwaters to the mouth (Segment MT41I006_160, 7.8 miles) was listed as impaired on the Montana 1996 303(d) list because of siltation. Coldwater fisheries were the listed impaired beneficial uses. In 2002 and 2004, aquatic life and coldwater fishery beneficial uses were listed as impaired because of metals, nutrients, and siltation. The additional analyses and evaluations described in Volume I found that nutrients, sediment (siltation), copper, and lead are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.2.5 of the Volume I Report).

Conceptual restoration strategies and the required TMDL elements for nutrients, sediment, and metals (i.e., copper and lead) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix C, D, E, F, and K.

9.1 METALS

The available water chemistry data suggest that Sevenmile Creek is impaired due to arsenic, copper, and lead. TMDLs are presented in the following sections to address the arsenic, copper, and lead impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

9.1.1 Sources of Metals in the Sevenmile Creek Watershed

Historic mining activities comprise the most significant source of metals to Sevenmile Creek. Most of the drainage area falls within the Scratchgravel Hills and Austin mining districts. The MBMG Abandoned and Inactive Mines database reports mineral location, placer, surface, surface-underground, underground, and other unknown" mining activities in the watershed. The historical mining types include placer, lode, and stockpile. In the past these mines produced gold, iron, lead, silver, copper, manganese, and arsenic. None of the mines in the immediate drainage area of this segment are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. The Helena National Forest documented evidence of placer mining and one mine waste rock dump within the stream bankfull width in Skelly Gulch, a tributary of Sevenmile Creek, during the source assessment. Modeled sources and their metals loadings to Sevenmile Creek are presented in Figure 9-1 through Figure 9-3.

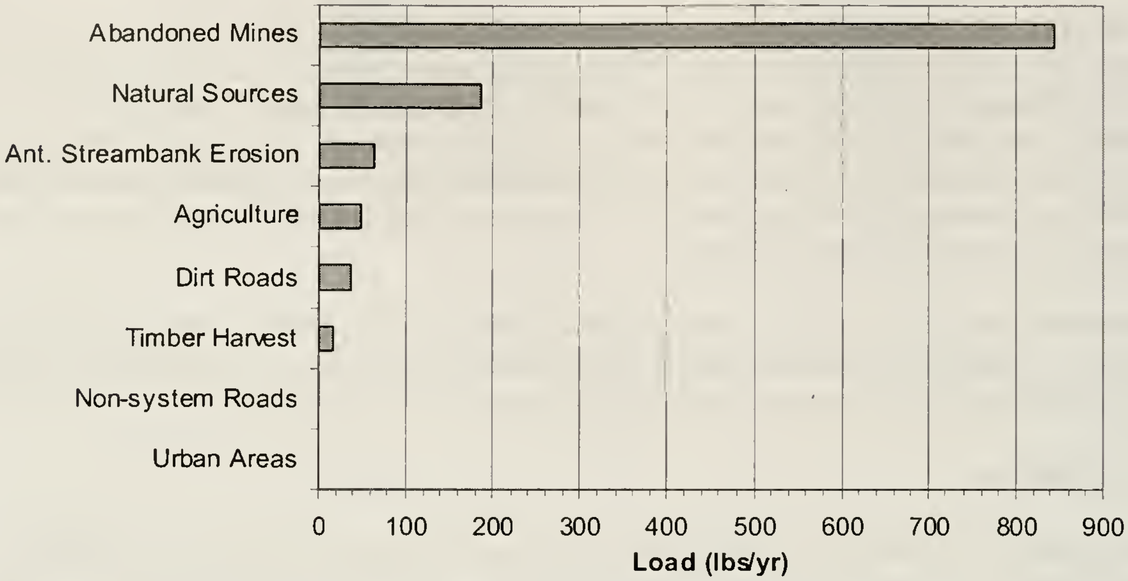

Figure 9-1. Sources of arsenic loadings to Sevenmile Creek.

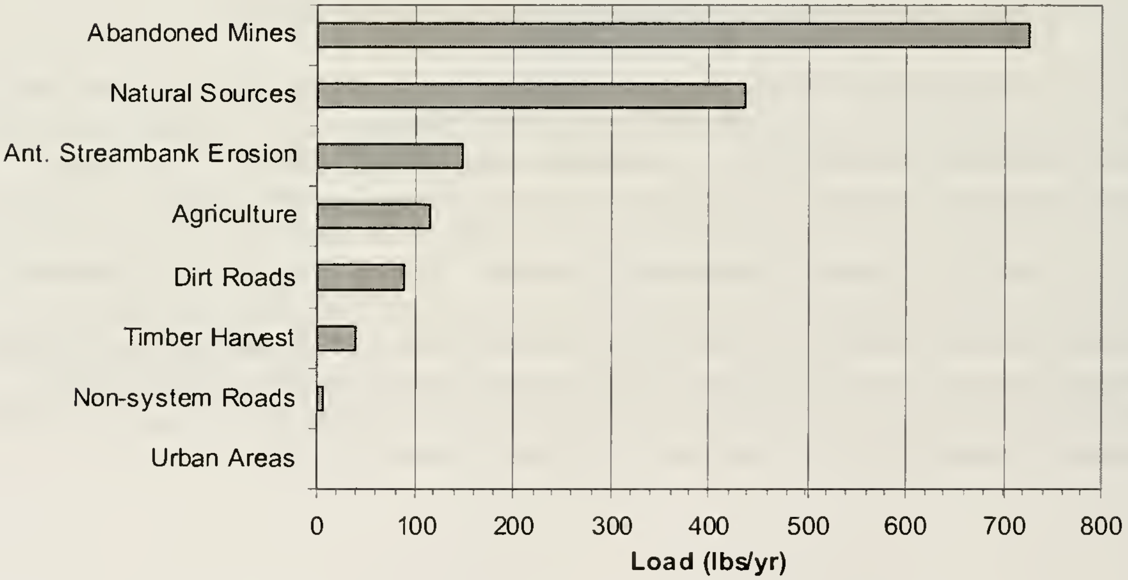

Figure 9-2. Sources of copper loadings to Sevenmile Creek.

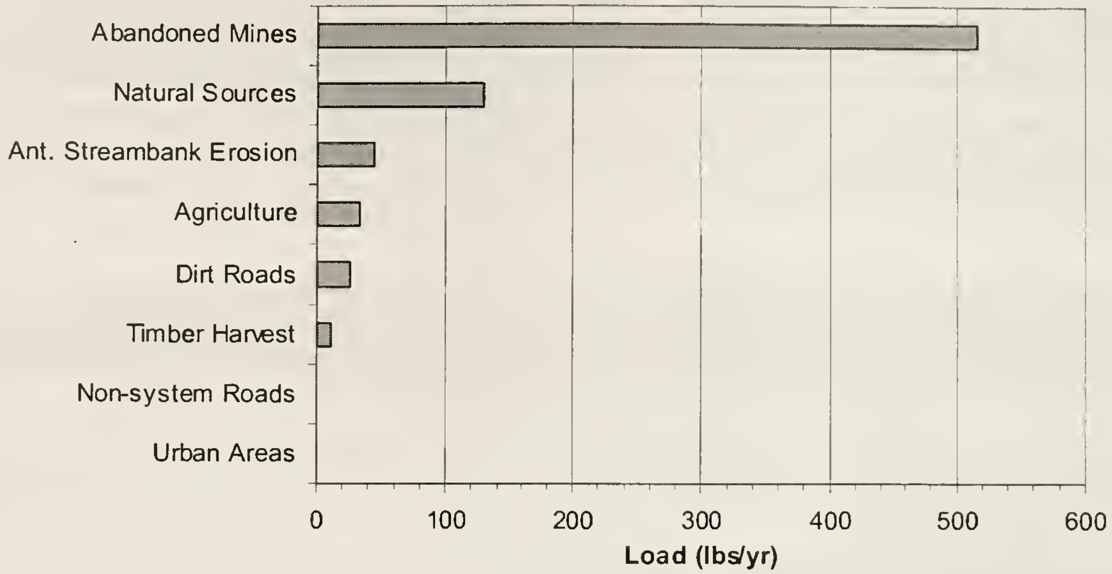

Figure 9-3. Sources of lead loadings to Sevenmile Creek.

9.1.2 Water Quality Goals/Targets

The ultimate goal of these metals TMDL is to attain and maintain the applicable Montana numeric standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Sevenmile Creek are presented in Table 9-1.

Table 9-1. Montana numeric surface water quality standards for metals in Sevenmile Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10 [d]
Copper (TR)	33.6 at 256.4 mg/L hardness[c]	20.4 at 256.4 mg/L hardness[c]	1,300
Lead (TR)	266.2 at 256.4 mg/L hardness[c]	10.3 at 256.4 mg/L hardness[c]	15

Note: TR = total recoverable.

[a] Maximum allowable concentration.

[b] No 4-day (96-hour) or longer period average concentration may exceed these values.

[c] The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).

[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

9.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 9-2 though Table 9-4. Based on the results of the source assessment (Section 9.1.1), the recommended implementation strategy to address the metals problem in Sevenmile Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 9-2 though Table 9-4, the hypothesis is that an overall, watershed scale metals load reduction of 52, 47, and 63 percent for arsenic, copper, and lead, respectively, will result in achievement of the applicable water quality standards. Sevenmile Creek already meets applicable water quality standards for cadmium and zinc. The proposal for achieving the load reduction is to reduce loads from mining sources 58, 58, and 75 percent for arsenic, copper, and lead, respectively.

Table 9-2. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	844.8	58	354.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	49.7	64	18.0	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	63.7	94	3.7	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 94% (see Table 9-7), thereby reducing sediment associated metals loads from streambank erosion by 94%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	2.9	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	16.5	97	0.5	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	38.3	60	15.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 9-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.3	80	0.3	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 9-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,017.2	61	392.0		
	Natural Sources	186.6	0	186.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Sevenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**1,203.8**	**52**	**578.7**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 392.0 lbs/yr + 186.6 lbs/yr + 0 = 578.7 lbs/yr** **TMDL = 0 + 1.1 lbs/day + 0.5 lbs/day + 0 = 1.6 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 9-3. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	725.1	58	302.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	116.3	64	42.2	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	149.2	94	8.7	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 94% (see Table 9-7), thereby reducing sediment associated metals loads from streambank erosion by 94%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	6.9	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	38.7	97	1.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	89.6	60	35.8	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 9-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	3.0	80	0.6	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 9-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,128.8	65.4	391		
	Natural Sources	437.0	0	437	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of copper in the Sevenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**1,565.8**	**47**	**828**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 391 lbs/yr + 437 lbs/yr + 0 = 828 lbs/yr** **TMDL = 0 + 1.1 lbs/day + 1.2 lbs/day + 0 = 2.3 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 9-4. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	516.1	75	127.0	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	34.7	64	12.6	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	44.5	94	2.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 94% (see Table 9-7), thereby reducing sediment associated metals loads from streambank erosion by 94%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	2.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	11.5	97	0.3	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	26.7	60	10.7	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 9-7).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.9	80	0.2	It is assumed that urban BMPs will reduce sediment loads by 80% (see Table 9-7), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	636.4	76	153.4		
	Natural Sources	130.3	0	130.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Sevenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**766.7**	**63**	**283.7**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 153.4 lbs/yr + 130.3 lbs/yr + 0 = 283.7 lbs/yr** **TMDL = 0 + 0.42 lbs/day + 0.36 lbs/day + 0 = 0.78 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

9.2 NUTRIENTS

The weight of evidence suggests that Sevenmile Creek (from headwaters to mouth) is impaired by nutrients (see Volume I Report). TMDLs are presented in the following sections to address the nutrient impairment. In the absence of a strong case for either N or P limitation in the ultimate receiving water body (i.e., Lake Helena), TMDLs are presented below for both TN and TP.

9.2.1 Nitrogen

9.2.1.1 Sources of Nitrogen in the Sevenmile Creek Watershed

As shown in Figure 9-4, based on the watershed scale modeling analysis (See Appendix C), the primary anthropogenic sources of nitrogen in the Sevenmile Creek watershed, in order of importance, are septic systems, urban areas, anthropogenic streambank erosion, dirt roads, and timber harvest activities. Additionally, Diffuse sediment and possibly nutrient sources from rural housing and stream dewatering were noted in the 2003 source assessment as potential sources of nutrients at the local scale (See Volume I).

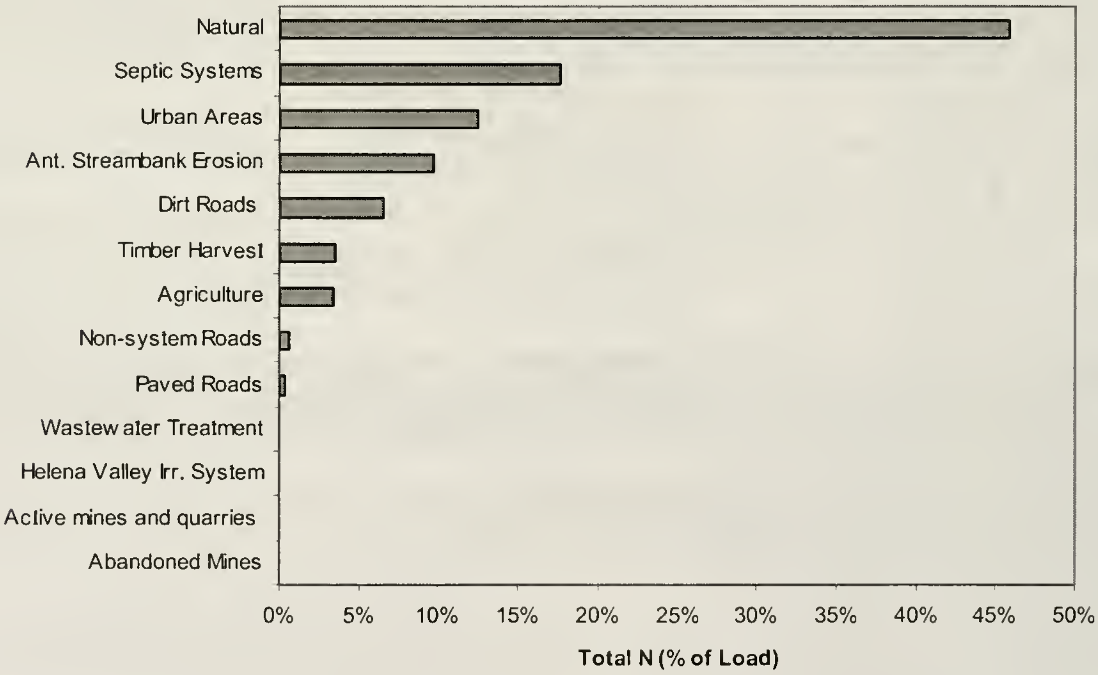

Figure 9-4. Percent of the annual TN load from all potentially significant sources in the Sevenmile Creek Watershed.

9.2.1.2 Water Quality Goals/Targets

The proposed interim water quality target for TN in Sevenmile Creek is 0.33 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

9.2.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations, and margin of safety are presented in Table 9-5. Based on the results of the source assessment (Section 9.2.1.1), the recommended implementation strategy to address the nitrogen problem in Sevenmile Creek is to reduce sediment-associated nitrogen loading from the primary anthropogenic sediment sources – anthropogenic bank erosion, dirt roads, and timber harvest. Though citizen education of proper septic system operation and maintenance will likely reduce phosphorus and bacterial loading from septic systems, the reduction in nitrogen loading is insignificant because even properly functioning septic systems have poor nitrogen removal. It is not likely that City sewer will expand to this subwatershed, so nitrogen loads from septic systems will likely not be reduced.

As shown in Table 9-5, the hypothesis is that an overall, watershed scale nitrogen load reduction of 65 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce sediment loads from current timber harvest by 97 percent, dirt roads by 60 percent, non system roads by 100 percent, agriculture 55 percent, urban areas 30 percent, and anthropogenic bank erosion by 94 percent, which will in turn decrease loading of sorbed nitrogen. In combination, these reductions are predicted to reduce the total nitrogen by 21 percent.

The goal of the nitrogen TMDL is to attain full beneficial use support in Sevenmile Creek. In the absence of better data/information, the interim target presented in Section 9.2.1.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 58 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable nitrogen load reduction for the Sevenmile Creek Watershed is estimated to be only 20 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Sevenmile Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TN load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TN target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 9-5. The adaptive management strategy is presented in Volume II, Section 3.2.3.1.

Table 9-5. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Nitrogen.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Agriculture	1.49	50	0.67	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	0.53	94	0.03	It is estimated that there are 5.3 miles of eroding stream banks in the watershed caused by a variety of human activities It is assumed that bank erosion will be returned to reference levels based on BEHI values	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.09	100	0.00	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	0.06	30	0.04	An average nitrogen removal efficiency of 30% is assumed based on the literature for urban areas (CWP, 2000)	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	2.74	0.4	2.73	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 0.4% decrease in TN Replacing failing septic systems with level 2 treatment could result in a 1.6% reduction in TN.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	0.55	97	0.02	It is assumed that nitrogen loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, nitrogen reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1.01	60	0.40	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding nitrogen load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.93	30	1.35	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average nitrogen removal efficiency of 30% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	8.40	38	5.24		
	Natural Sources	7.02	0	7.02	It is assumed that the nitrogen loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0.00	0	0.00	There are no point sources of nitrogen in the Sevenmile Creek Watershed.	
Margin of Safety		NA	0	0.00	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**15.42**	**21**	**12.26**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 5.24 tons/yr + 7.02 tons/yr + 0 = 12.26 tons/yr** **TMDL = 0 + 0.014 tons/day + 0.019 tons/day + 0 = 0.033 tons/day**					

9.2.2 Phosphorus

9.2.2.1 Sources of Phosphorus in the Sevenmile Creek Watershed

As shown in Figure 9-5, based on the watershed scale modeling analysis (See Appendix C), the primary anthropogenic sources of phosphorus in the Sevenmile Creek watershed, in order of importance, are anthropogenic streambank erosion, dirt roads, urban areas, timber harvest, and agriculture. Additionally, Mine reclamation, horse pastures/riparian grazing and streambank stability problems were noted as potential nutrient sources in the 2003 source assessment as potential sources of nutrients at the local scale (See Volume I). Dirt roads were cited as a major contributor to sediment loading in streams. Diffuse sediment and possibly nutrient sources from rural housing and stream dewatering were noted in the 2003 source assessment for potential nutrient sources.

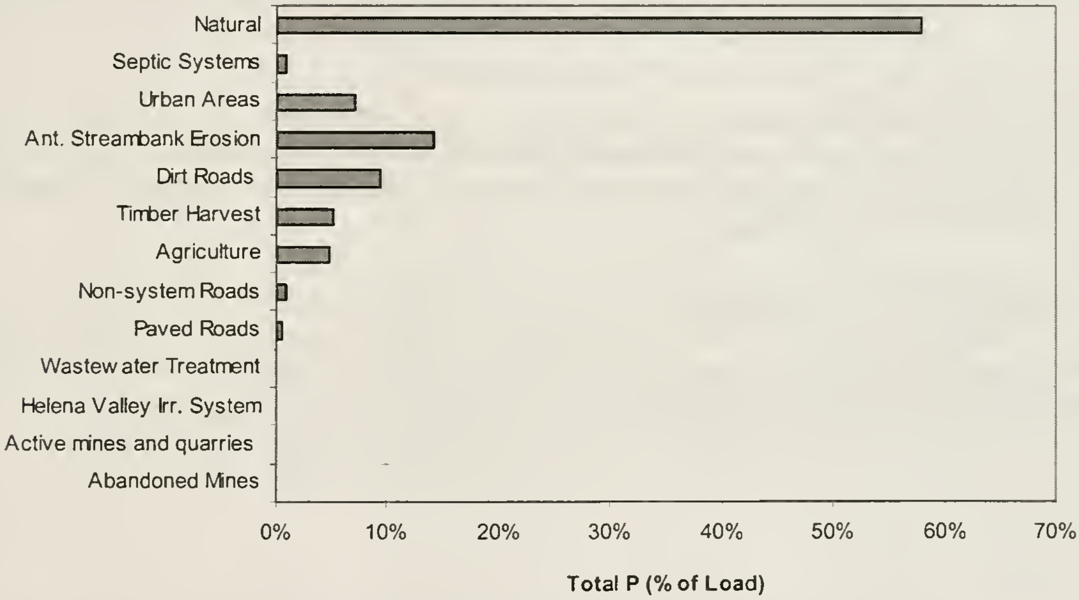

Figure 9-5. Percent of the annual TP load from all potentially significant sources in the Sevenmile Creek Watershed.

9.2.2.2 Water Quality Goals/Targets

The proposed interim water quality target for TP in Spring Creek is 0.04 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

9.2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the phosphorus TMDL is to attain full beneficial use support in Sevenmile Creek. In the absence of better data/information, the interim target presented in Section 9.2.2.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A TP load reduction of 79 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable phosphorus load reduction for the Spring Creek Watershed is estimated to be only 32 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Sevenmile Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TP load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TP target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 9-6. The adaptive management strategy is presented in Volume II, Section 3.2.3.1.

Table 9-6. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Phosphorus.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
LA	Agriculture	0.11	55	0.05	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	0.33	94	0.02	It is estimated that there are 5.3 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels Therefore, this load reduction may be an overestimate
	Non-system Roads	0.02	100	0.00	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	0.01	50	0.01	An average phosphorus removal efficiency of 50% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	0.02	100	0.00	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 100% decrease in TP.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	0.12	97	0.00	It is assumed that phosphorus loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, phosphorus reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.22	60	0.09	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding phosphorus load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.16	50	0.08	The effectiveness of urban storm water BMPs has been well studied It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average phosphorus removal efficiency of 50% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	0.99	75	0.25		
	Natural Sources	1.34	0	1.34	It is assumed that the phosphorus loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	All Point Sources	0	0	0	There are no point sources of phosphorus in the Sevenmile Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		2.33	32	1.59		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 0.25 tons/yr + 1.34 tons/yr + 0 = 1.59 tons/yr** **TMDL = 0 + 0.0007 tons/day + 0.0037 tons/day + 0 = 0.0044 tons/day**					

9.3 SEDIMENT

The weight of evidence suggests that Sevenmile Creek (from headwaters to mouth) is impaired by sediment/siltation (see Volume I Report). TMDLs are presented in the following sections to address the sediment impairment. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

9.3.1 Sources of Sediment in the Sevenmile Creek Watershed

As shown in Figure 9-6, the primary anthropogenic sources of sediment in the Sevenmile Creek watershed, in order of sediment load are, anthropogenic streambank erosion, unpaved roads, timber harvest, agriculture, non-system roads/trails, and urban areas.

Anthropogenic streambank erosion occurs throughout Sevenmile Creek. This sediment source is largely a result of riparian grazing impacts, animal feedlot/confinement areas, road and railroad encroachment, stream channelization, beaver dam removal and historic mining activity. Sediment from unpaved roads was the second largest anthropogenic sediment source in the segment. Sediment is entering at road crossings along the main stem and tributaries. Timber harvest activities have occurred in the uplands of the watershed on DNRC and BLM lands. Watershed modeling shows erosion from agricultural activities occurring throughout the central and lower watershed. Non-system roads/trails were observed in the uplands of the Sevenmile Creek watershed. The lack of drainage structures on these roads can lead to disproportionately large volumes of sediment being generated from this source.

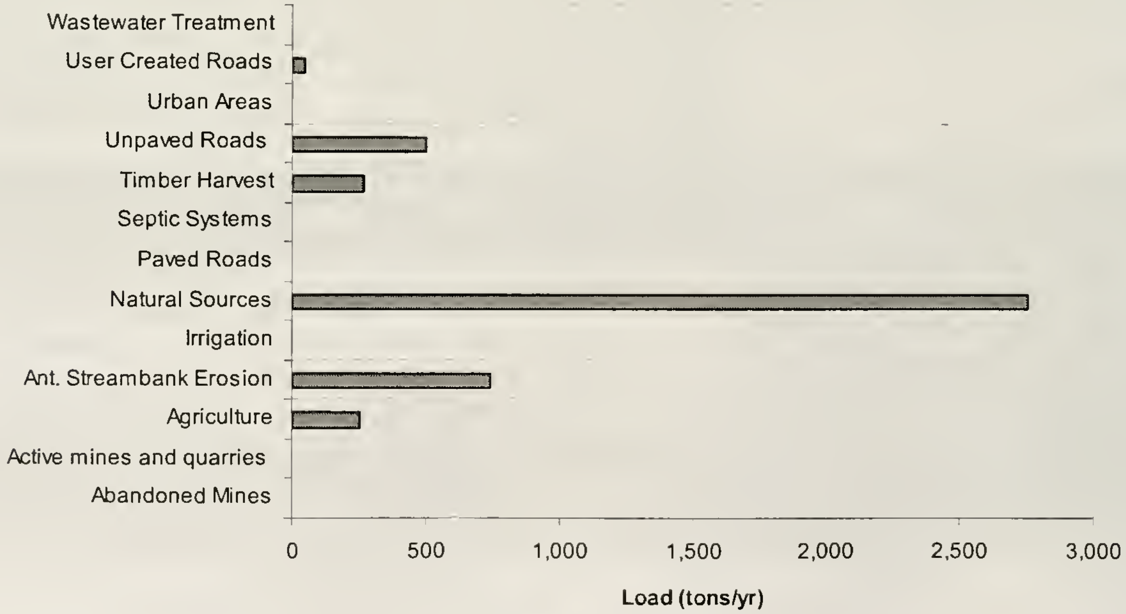

Figure 9-6. Total annual sediment load from all potentially significant sources in the Sevenmile Creek Watershed.

9.3.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

9.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 9-7. Based on the results of the source assessment (Section 9.3.1), the recommended implementation strategy to address the siltation problem in Sevenmile Creek is to reduce sediment loading from the primary anthropogenic sediment sources – anthropogenic streambank erosion, unpaved roads, timber harvest, agriculture, non-system roads, and urban areas. As shown in Table 9-7, the hypothesis is that an overall, watershed scale sediment load reduction of 33 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current anthropogenic streambank erosion, unpaved roads, timber harvest, agriculture, non-system roads, and urban areas by 97, 60, 97, 60, 100, and 80 percent, respectively.

Table 9-7. TMDL, Allocations, and Margin of Safety for Sevenmile Creek – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Agriculture	257	60	93	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil erosion.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	743	94	44	It is estimated that there are 5.3 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	46	100	0	All non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads. Therefore, this load reduction may be an overestimate.
	Timber Harvest	270	97	8	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	504	60	202	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	5	80	1	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,825	83	348		
	Natural Sources	2,752	0	2,752	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Sevenmile Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		4,577	33	3,100		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 348 tons/yr + 2,752 tons/yr + 0 = 3,100 tons/yr** **TMDL = 0 + 1.0 tons/day + 7.5 tons/day + 0 = 8.5 tons/day**					

10.0 SILVER CREEK

Silver Creek from the headwaters to the mouth (Segment MT41I006_150, 21.6 miles) was listed as impaired on the Montana 1996 303(d) list because of metals and priority organics. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002 and 2004, aquatic life, coldwater fisheries, and drinking water supply beneficial uses were listed as impaired because of metals and priority organics. The additional analyses and evaluations described in Volume I found that arsenic is currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.3.2 of the Volume I Report). Priority organics are not impairing beneficial uses, and therefore no TMDL will be presented.

Conceptual restoration strategies and the required TMDL elements for arsenic are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix E and F.

10.1 METALS

The water chemistry data suggest that Silver Creek is impaired by arsenic. TMDLs are presented in the following sections to address the arsenic impairment. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

10.1.1 Sources of Metals in the Silver Creek Watershed

Besides sediment-associated metals sources, significant contributors of metals to the stream segment are upstream sources and historical hard rock mining activities in the upper watershed. Jennie's Fork is a tributary and contributes to the metals loads. The sub-watershed falls within the Marysville, Scratchgravel Hills, and Austin mining districts. The MBMG Abandoned and Inactive Mines database reports mineral location, placer, prospect, surface, surface-underground, and underground mining activities in the watershed. The historical mining types include lode, mill, and placer. In the past these mines produced gold, silver, manganese, lead, iron, copper, and zinc. Five mine sites in the watershed are listed in the State of Montana’s inventory of High Priority Abandoned Hardrock Mine Sites and fall within the Marysville district: Goldsil Mill Site, Drumlummon Mine/Mine Site, Argo Mill Site, Drumlummon Mine/Mill Site, and Belmont. Modeled sources and their arsenic loadings to Silver Creek are presented in Figure 10-1.

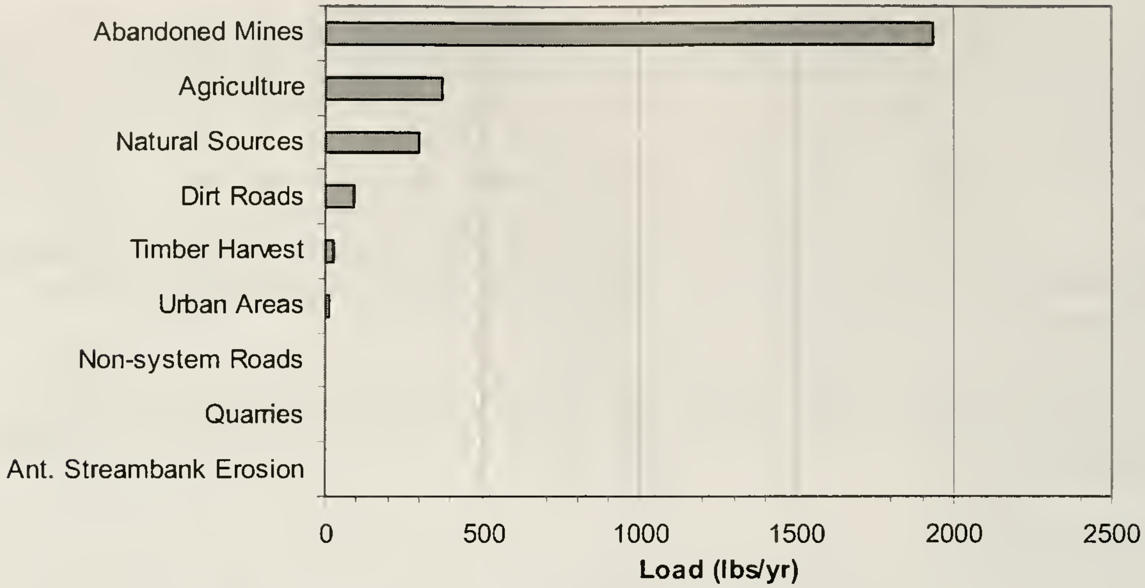

Figure 10-1. Sources of arsenic loadings to Silver Creek.

10.1.2 Water Quality Goals/Targets

The ultimate goal of this TMDL is to attain and maintain the applicable Montana numeric standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Silver Creek are presented in Table 10-1.

Table 10-1. Montana numeric surface water quality standards for metals in Silver Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[c]
Arsenic (TR)	340	150	10[d]

Note: TR = total recoverable.
[a] Maximum allowable concentration.
[b] No 4-day (96-hour) or longer period average concentration may exceed these values.
[c] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

10.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 10-2. Based on the results of the source assessment (Section 10.1.1), the recommended implementation strategy to address the metals problem in Silver Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 10-2, the hypothesis is that an overall, watershed scale metals load reduction of 65 percent for arsenic will result in achievement of the applicable water quality standards. Silver Creek already meets applicable water quality standards for cadmium, copper, lead, and zinc. The proposal for achieving the load reduction is to reduce loads from mining sources by 70 percent for arsenic.

Table 10-2. TMDL, Allocations, and Margin of Safety for Silver Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	1,936.1	70	580.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	371.9	88	44.6	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	0.3	44	0.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 44%, thereby reducing sediment associated metals loads from streambank erosion by 44%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	7.2	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	2.0	0	2.0	Only the portion of land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	25.7	97	0.8	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	94.1	60	37.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	16.1	80	3.2	It is assumed that urban BMPs will reduce sediment loads by 80), thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	2,453.4	72	669		
	Natural Sources	299.1	0	299	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Silver Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		2,752.5	65	**968**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 669 lbs/yr + 299 lbs/yr + 0 = 968 lbs/yr** **TMDL = 0 + 1.8 lbs/day + 0.8 lbs/day + 0 = 2.6 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

11.0 SKELLY GULCH

Skelly Gulch from the headwaters to the mouth (Segment MT41I006_220, 7.7 miles) was listed as impaired on the Montana 1996 303(d) list because of siltation. Aquatic life and coldwater fisheries were the listed impaired beneficial uses. In 2002 and 2004, aquatic life, coldwater fisheries, and drinking water supply beneficial uses were listed as impaired because of metals and siltation. The additional analyses and evaluations described in Volume I found that sediment (siltation) is currently impairing aquatic life and fishery beneficial uses (see Section 3.4.2.4 of the Volume I Report). There were insufficient credible data to determine if metals are impairing beneficial uses, and no TMDLs are presented at this time. Additional monitoring is proposed in Appendix H.

Conceptual restoration strategies and the required TMDL elements for sediment are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D.

11.1 SEDIMENT

The weight of evidence suggests that Skelly Gulch is impaired because of sediment (siltation). TMDLs are presented in the following sections to address the siltation impairment. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

11.1.1 Sources of Sediment in the Skelly Gulch Watershed

As shown in Figure 11-1, the primary anthropogenic sources of sediment in the Skelly Gulch watershed, in order of sediment load are: unpaved roads, timber harvest, anthropogenic streambank erosion, and non-system roads.

Throughout much of the lower portion of the segment length, Skelly Gulch Road (unpaved) is adjacent to the stream with minimal, if any, riparian buffer width. In the central watershed, the road is elevated away from the channel and likely ceases to be, or is a reduced sediment source. However, the road crosses Skelly Gulch in this area via bridge and a stream ford. Sediment is undoubtedly entering at the stream ford location. Upstream of this crossing, the road again is elevated away from the channel and is likely not contributing sediment between this area and the Helena National Forest property boundary. Five road crossings related to timber harvest units were identified as sediment sources within Helena National Forest ownership. Timber harvest activities have occurred in the upper watershed on Helena National Forest property. Evidence of historic timber harvest was observed in the central area of the watershed. Observed streambank erosion is largely the result of riparian grazing, road encroachment, stream channelization and historic mining activity. Non-system roads/trails were observed in the central watershed. These features are problematic sediment sources because they lack any run-off diversion structures.

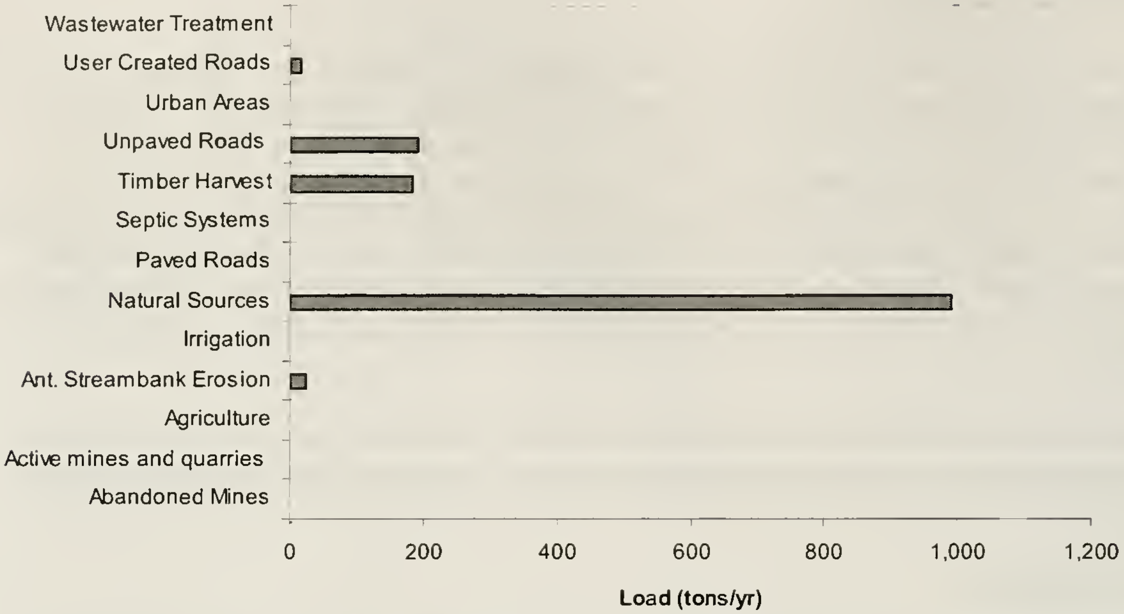

Figure 11-1. Total annual sediment load from all potentially significant sediment sources in the Skelly Gulch Watershed.

11.1.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume 1, Section 3.1.3.

11.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 11-1. Based on the results of the source assessment (Section 11.1.1), the recommended implementation strategy to address the siltation problem in Skelly Gulch is to reduce sediment loading from the primary anthropogenic sediment sources – unpaved roads, timber harvest, anthropogenic streambank erosion, and non-system roads. As shown in Table 11-1, the hypothesis is that an overall, watershed scale sediment load reduction of 22 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current unpaved roads, timber harvest, and non-system roads by 60, 97, and 100 percent, respectively. Modeled streambank erosion sediment load currently related to anthropogenic sources is essentially the same value as that modeled for reference conditions (within 0.4 tons which is well within the margin of error for the modeling exercise). Based on the near reference condition of the anthropogenic streambank load, no reduction in this source category is advised. However, all efforts should be made to eliminate any and all sources of human caused streambank erosion.

Table 11-1. TMDL, Allocations, and Margin of Safety for Skelly Gulch – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Anthropogenic Streambank Erosion	24	0.0	24	It is estimated that there are 1.0 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	17	100	0	All non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads. Therefore, this load reduction may be an overestimate.
	Timber Harvest	183	97	5	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	192	60	77	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	416	76	106		
	Natural Sources	991	0	991	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Skelly Gulch Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total[1]		**1,407**	**22**	**1,097**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 106 tons/yr + 991 tons/yr + 0 = 1,097 tons/yr** **TMDL = 0 + 0.3 tons/day + 2.7 tons/day + 0 = 3.0 tons/day**					

12.0 SPRING CREEK

Spring Creek from Corbin Creek to the mouth (Segment MT41I006_080, 1.7 miles) was listed as impaired on the Montana 1996 303(d) list because of suspended solids, nutrients, metals, and pH. Aquatic life, coldwater fisheries, and drinking water beneficial uses were listed as impaired. In 2002, aquatic life, coldwater fisheries, and drinking water supply beneficial uses were listed as impaired because of metals. Spring Creek did not appear on the 2004-303(d) list because of insufficient credible data. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, copper, lead, zinc, nutrients, and sediment (suspended solids) are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.8 of the Volume I Report). pH is not impairing beneficial uses, and therefore no TMDL will be presented.

Conceptual restoration strategies and the required TMDL elements for nutrients, sediment, and metals (i.e., arsenic, cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix C, D, E, F, and G.

12.1 METALS

The available metals data suggest that Spring Creek is impaired by arsenic, cadmium, copper, lead, and zinc. TMDLs are presented in the following sections to address the arsenic, cadmium, copper, lead, and zinc impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

12.1.1 Sources of Metals in the Spring Creek Watershed

Besides anthropogenic sediment-associated metals sources, relevant sources of metals to Spring Creek include Corbin Creek, historical mining activities in the immediate drainage area, and possibly, the Montana Tunnels Mine in the headwaters of the watershed. Flow from Corbin Creek and historical mill tailings deposits throughout the watershed are contributors of metals to the stream. Most of the drainage area falls within the Colorado mining district, although there is a small section in the Clancy mining district. The MBMG Abandoned and Inactive Mines database shows mineral location and underground mining activities in the drainage area of the stream. The historical mining types include lode, placer, and mill. In the past these mines produced silver, copper, lead, zinc, gold, and uranium. Within the basin, the Corbin Flats Mine is listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites. Three other mines in the Colorado mining district and upstream of the listed segment are also listed in State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites: Washington, Bluebird, and the Wickes Smelter.

NPDES Permit MT0028428 Montana Tunnels Mine is permitted to discharge arsenic, cadmium, copper, lead and zinc to the stream. Current permit limits are 290ug/L for arsenic, 4ug/L for cadmium, 10ug/L for copper, 50 ug/L for lead, and 120 ug/L for zinc. The permit limit for arsenic is 29 times greater than the human health criteria for arsenic. It should be noted, however that this facility recycles all the water used, and according to PCS, no discharge has ever been observed from this facility.

Modeled sources and their metals loadings to Spring Creek are presented in Figure 12-1 through Figure 12-5.

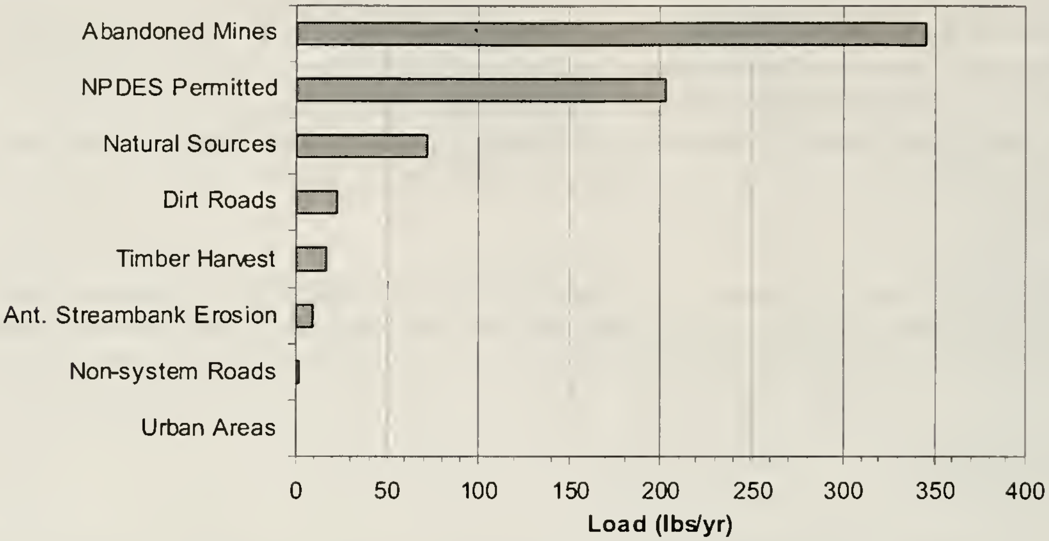

Figure 12-1. Sources of arsenic loadings to Spring Creek.

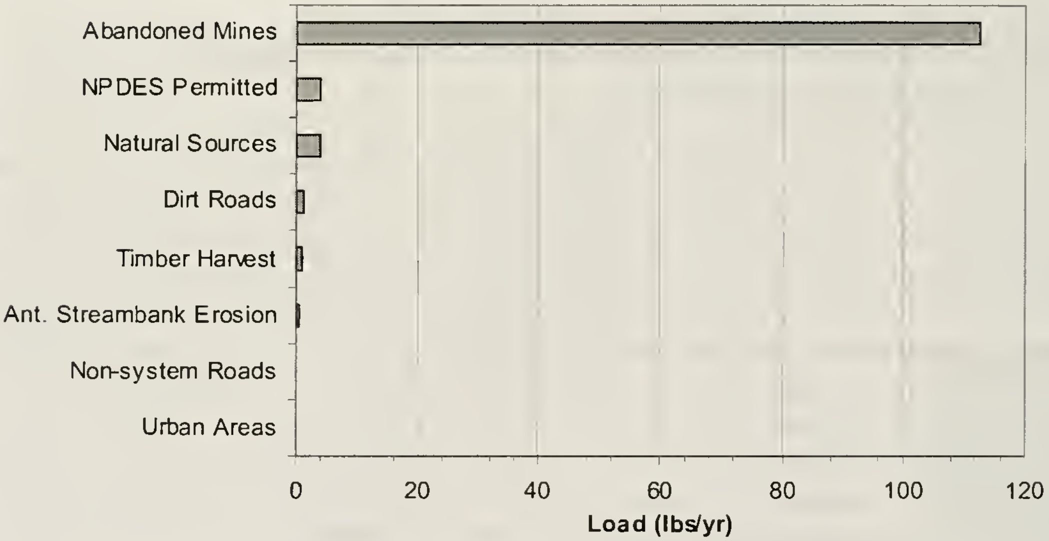

Figure 12-2. Sources of cadmium loadings to Spring Creek.

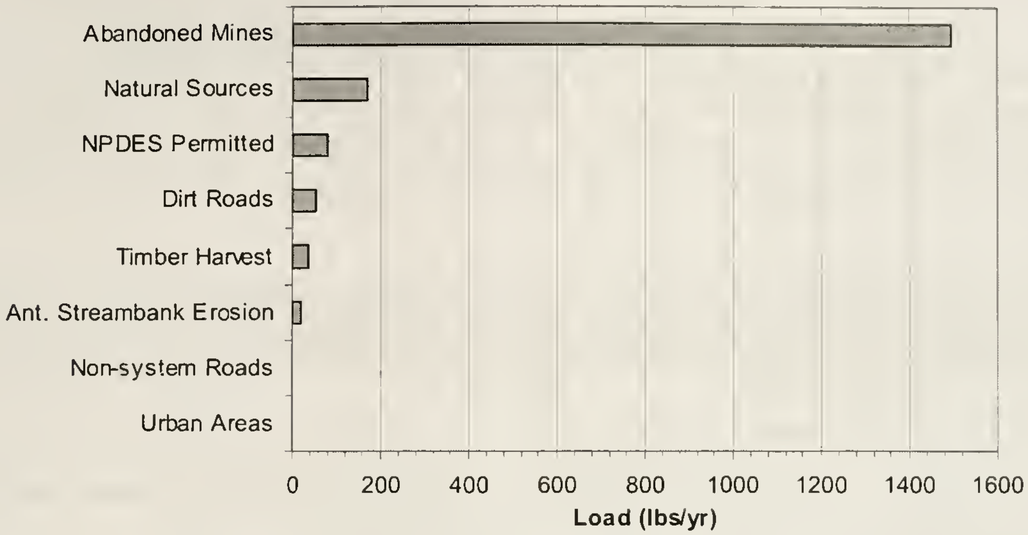

Figure 12-3. Sources of copper loadings to Spring Creek.

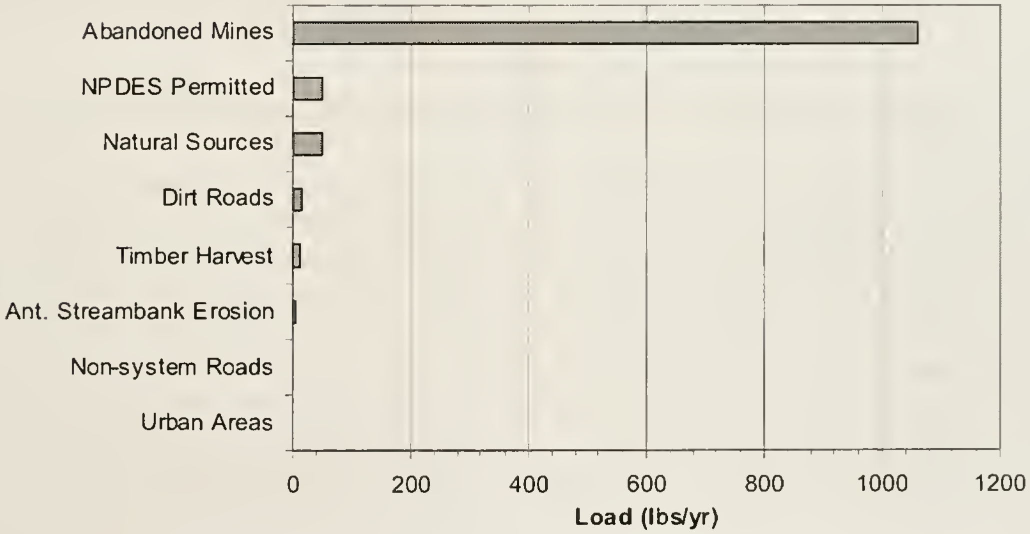

Figure 12-4. Sources of lead loadings to Spring Creek.

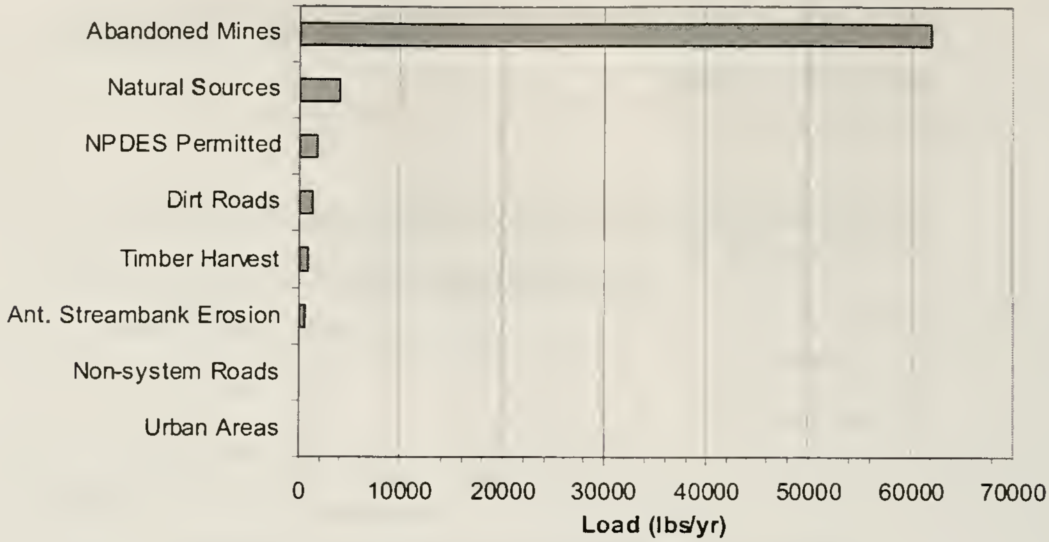

Figure 12-5. Sources of zinc loadings to Spring Creek.

12.1.2 Water Quality Goals/Targets

The ultimate goal of theses metals TMDL is to attain and maintain the applicable Montana numeric standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Spring Creek are presented in Table 12-1.

Table 12-1. Montana numeric surface water quality standards for metals in Spring Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10 [d]
Cadmium (TR)	8.95 at 400 mg/L hardness[c]	0.75 at 400 mg/L hardness[c]	5
Copper (TR)	51.0 at 400 mg/L hardness[c]	29.8 at 400 mg/L hardness[c]	1,300
Lead (TR)	468.3 at 400 mg/L hardness[c]	18.2 at 400 mg/L hardness[c]	15
Zinc (TR)	392.6 at 400 mg/L hardness[c]	392.6 at 400 mg/L hardness[c]	2,000

Note: TR = total recoverable.
[a] Maximum allowable concentration.
[b] No 4-day (96-hour) or longer period average concentration may exceed these values.
[c] The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).
[d] The human health standard for arsenic is currently 18 µg/L, but will change to 10 µg/L in 2006.

12.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 12-2 through Table 12-6. Based on the results of the source assessment (Section 12.1.1), the recommended implementation strategy to address the metals problem in Spring Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Table 12-2 through Table 12-6, the hypothesis is that an overall, watershed scale metals load reduction of 56, 87, 64, 82, and 81 percent for arsenic, cadmium, copper, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from historical mining sources by 62, 94, 73, 90, and 94 percent for arsenic, cadmium, copper, lead, and zinc, respectively. A reduction of 60 percent in permitted arsenic load from the Montana Tunnels Mine is also recommended.

Table 12-2. TMDL, Allocations, and Margin of Safety for Spring Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	345.2	62	131.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	9.6	97	0.3	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 97% (see Table 12-9), thereby reducing sediment associated metals loads from streambank erosion by 97%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	1.7	100	0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	16.7	97	0.5	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	22.5	60	9.0	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 12-9).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	395.7	64	141.0		
	Natural Sources	72.4	0	72.4	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	203.1	60	81.2	Montana Tunnels is the only point source in the watershed. Current permit limits applied to permitted facility effluent.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**671.2**	**56**	**294.6**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 81.2 + 141.0 lbs/yr + 72.4 lbs/yr + 0 = 294.6 lbs/yr** **TMDL = 0.22 + 0.39 lbs/day + 0.20 lbs/day + 0 = 0.81 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 12-3. TMDL, Allocations, and Margin of Safety for Spring Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	112.6	94	7.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	0.5	97	0.0	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 97% (see Table 12-9), thereby reducing sediment associated metals loads from streambank erosion by 97%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.1	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.9	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1.3	60	0.5	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 12-9).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	115.4	93	7.7		
	Natural Sources	4.1	0	4.1	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	4.1	0	4.1	Montana Tunnels is the only point source in the watershed. Current permit limits applied to permitted facility effluent.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**123.6**	**87**	**15.9**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 4.1 + 7.7 lbs/yr + 4.1 lbs/yr + 0 = 15.9 lbs/yr** **TMDL = 0.011 + 0.021 lbs/day + 0.011 lbs/day + 0 = 0.043 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 12-4. TMDL, Allocations, and Margin of Safety for Spring Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	1,495.2	73	397.9	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	22.5	97	0.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 97% (see Table 12-9), thereby reducing sediment associated metals loads from streambank erosion by 97%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	4.0	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	39.0	97	1.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	52.7	60	21.1	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 12-9).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.1	80	0.0	An average 80% reduction for sediment-associated metals is assumed.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,613.5	74	420.8		
	Natural Sources	169.6	0	169.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	77.6	0	77.6	Montana Tunnels is the only point source in the watershed. Current permit limits applied to permitted facility effluent.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**1,860.7**	**64**	**668.0**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 77.6 + 420.8 lbs/yr + 169.6 lbs/yr + 0 = 668.0 lbs/yr** **TMDL = 0.22 + 1.15 lbs/day + 0.46 lbs/day + 0 = 1.83 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 12-5. TMDL, Allocations, and Margin of Safety for Spring Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	1,058.1	89	111.2	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	6.7	97	0.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 97% (see Table 12-9), thereby reducing sediment associated metals loads from streambank erosion by 97%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	1.2	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	11.6	97	0.4	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	15.7	60	6.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 12-9).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,093.3	89	118.1		
	Natural Sources	50.6	0	50.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	51.1	0	51.1	Montana Tunnels is the only point source in the watershed. Current permit limits applied to permitted facility effluent.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**1,195.0**	**82**	**219.8**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 51.1 + 118.1 lbs/yr + 50.6 lbs/yr + 0 = 219.8 lbs/yr** **TMDL = 0.14 + 0.32 lbs/day + 0.14 lbs/day + 0 = 0.60 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 12-6. TMDL, Allocations, and Margin of Safety for Spring Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	62,184.3	94	4,051.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	533.6	97	14.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 97% (see Table 12-9), thereby reducing sediment associated metals loads from streambank erosion by 97%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	95.7	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	924.3	97	29.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1,247.7	60	499.1	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 12-9).[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	3.1	80	0.62	An average 80% reduction for sediment-associated metals is assumed.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	69,006	87	8,612		
	Natural Sources	4,017	0	4,017	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	1,770	0	1,770	Montana Tunnels is the only point source in the watershed. Current permit limits applied to permitted facility effluent.	Actual discharge quantity and quality will likely be below that assumed. These loads are likely over-estimated.
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**74,793**	**81**	**14,399**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 1,770 + 8,612 lbs/yr + 4,017 lbs/yr + 0 = 14,399 lbs/yr** **TMDL = 4.8 + 23.6 lbs/day + 11.0 lbs/day + 0 = 39.4 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

12.2 NUTRIENTS

The weight of evidence suggests that Spring Creek is impaired because of nutrients. TMDLs are presented in the following sections to address the nutrient impairments. In the absence of a strong case for either N or P limitation in the ultimate receiving water bodies (i.e., Prickly Pear Creek and Lake Helena), TMDLs are presented below for both nitrogen and phosphorus.

12.2.1 Nitrogen

12.2.2 Sources of Nitrogen in the Spring Creek Watershed

As shown in Figure 12-6, based on the watershed scale modeling analysis (See Appendix C), the primary anthropogenic sources of nitrogen in the Spring Creek watershed, in order of importance, are dirt roads, septic systems, timber harvest, abandoned mines, and anthropogenic streambank erosion. Additionally, Mine reclamation, horse pastures/riparian grazing and streambank stability problems were noted in the 2003 source assessment as potential sources of nutrients at the local scale (See Volume I).

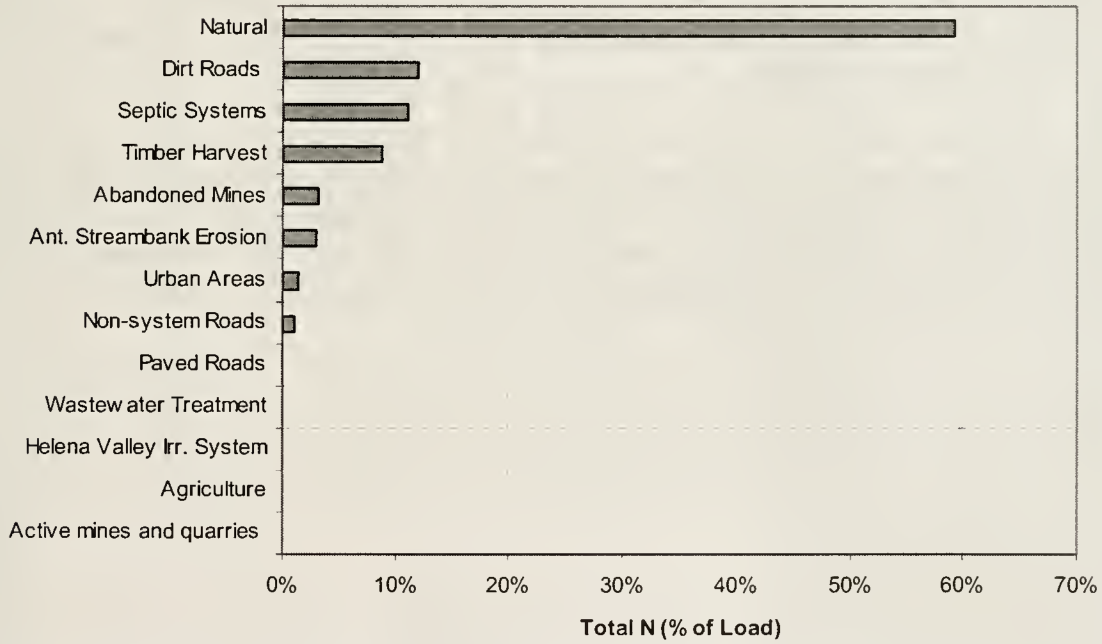

Figure 12-6. Percent of the total annual nitrogen load from all potentially significant nitrogen sources in the Spring Creek Watershed.

12.2.2.2 Water Quality Goals/Targets

The proposed interim water quality target for TN in Spring Creek is 0.33 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

12.2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the nitrogen TMDL is to attain full beneficial use support in Spring Creek. In the absence of better data/information, the interim target presented in Section 12.2.2.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 75 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable nitrogen load reduction for the Spring Creek Watershed is estimated to be only 22 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Spring Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TN load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TN target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 12-7. The adaptive management strategy is presented in Volume II, Section 3.2.3.1.

Table 12-7. TMDL, Allocations, and Margin of Safety for Spring Creek – Nitrogen.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.24	67	0.08	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 67%. Sediment-associated nitrogen will decrease accordingly (67%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated nitrogen reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	0.22	97	0.01	It is estimated that there are 4.4 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.08	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load raduction may be an overestimate.
	Septic Systems	0.85	1.2	0.84	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 1.2% decrease in TN. Replacing failing septic systems with level 2 treatment could result in a 2.6% reduction in TN.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated. No specific data were available about the actual percentage of failing systems.
	Timber Harvest	0.67	97	0.02	It is assumed that nitrogen loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, nitrogen reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.91	60	0.36	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding nitrogen load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.10	30	0.07	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average nitrogen removal efficiency of 30% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	3.07	55	1.38		
	Natural Sources	4.46	0	4.46	It is assumed that the nitrogen loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	The Montana Tunnels Mine is located in this watershed and has an NPDES permit. However, no surface water discharges have been recorded in the Montana DEQ permit records (1987-2005) and they are unlikely to occur.	It is possible (although unlikely) for a discharge from this facility to occur (e.g., due to equipment malfunction or an extreme storm event). The current load might therefore be under-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		7.53	22	5.84		
TMDL	**TMDL = WLA + LA + Natural + MOS TMDL = 0 + 1.38 tons/yr + 4.46 tons/yr + 0 = 5.84 tons/yr TMDL = 0 + 0.004 tons/day + 0.012 tons/day + 0 = 0.016 tons/day**					

12.2.3 Phosphorus

12.2.3.1 Sources of Phosphorus in the Spring Creek Watershed

As shown in Figure 12-7, based on the watershed scale modeling analysis (See Appendix C), the primary anthropogenic sources of phosphorus in the Spring Creek watershed, in order of importance, are dirt roads, timber harvest, abandoned mines, and anthropogenic streambank erosion. Additionally, mine reclamation, horse pastures/riparian grazing and streambank stability problems were noted in the 2003 source assessment as potential sources of nutrients at the local scale (See Volume I).

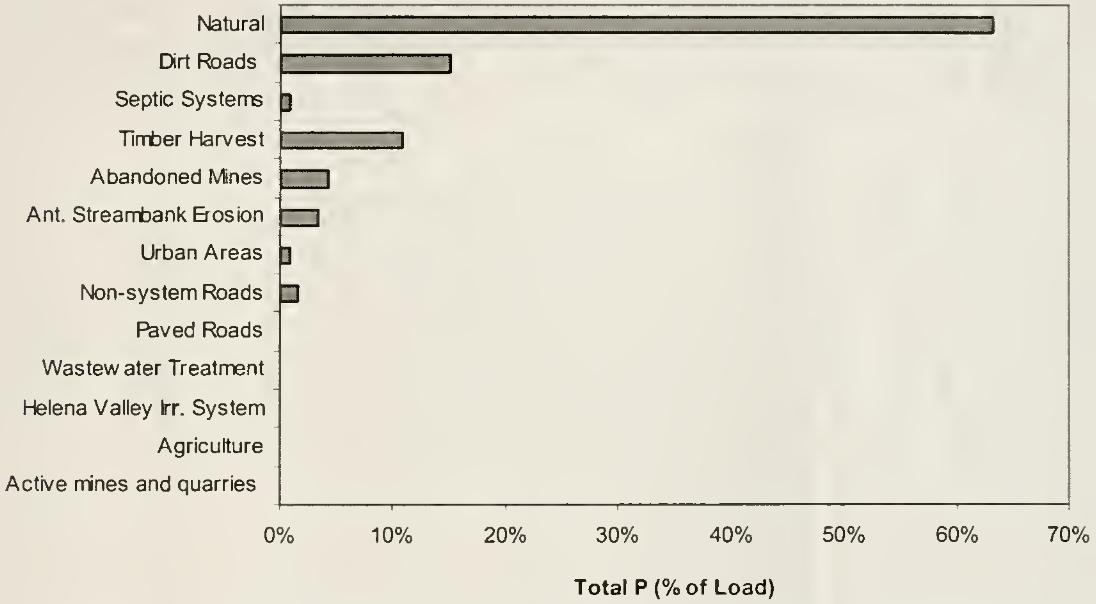

Figure 12-7. Percent of the total annual phosphorus load from all potentially significant phosphorus sources in the Spring Creek Watershed.

12.2.3.2 Water Quality Goals/Targets

The proposed interim water quality target for TP in Spring Creek is 0.04 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

12.2.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the phosphorus TMDL is to attain full beneficial use support in Spring Creek. In the absence of better data/information, the interim target presented in Section 12.2.3.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 83 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable phosphorus load reduction for the Spring Creek

Watershed is estimated to be only 29 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Spring Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TP load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TP target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 12-8. The adaptive management strategy is presented in Volume II, Section 3.2.3.1.

Table 12-8. TMDL, Allocations, and Margin of Safety for Spring Creek – Phosphorus.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.05	67	0.016	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 67%. Sediment-associated phosphorus will decrease accordingly (67%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated phosphorus reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	0.05	97	0.002	It is estimated that there are 4.4 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.02	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Septic Systems	0.01	100	0	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 100% decrease in TP.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	0.14	97	0.004	It is assumed that phosphorus loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, phosphorus reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.20	60	0.080	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding phosphorus load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.01	50	0.005	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average phosphorus removal efficiency of 50% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	0.48	79	0.11		
	Natural Sources	0.84	0	0.840	It is assumed that the phosphorus loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	The Montana Tunnels Mine is located in this watershed and has an NPDES permit. However, no surface water discharges have been recorded in the Montana DEQ permit records (1987-2005) and they are unlikely to occur.	It is possible (although unlikely) for a discharge from this facility to occur (e.g., due to equipment malfunction or an extreme storm event). The current load might therefore be under-estimated.
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**1.32**	**29**	**0.95**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0+ 0.11 tons/yr + 0.84 tons/yr + 0 = 0.95 tons/yr** **TMDL = 0 + 0.0003 tons/day + 0.0023 tons/day + 0 = 0.0026 tons/day**					

12.3 SEDIMENT

The weight of evidence suggests that Spring Creek is impaired because of siltation (see Volume I Report). TMDLs are presented in the following sections to address the sediment/siltation impairments. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

12.3.1 Sources of Sediment in the Spring Creek Watershed

As shown in Figure 12-8, the primary anthropogenic sources of sediment in the Spring Creek watershed, in order of sediment load are unpaved roads, timber harvest, abandoned mines, anthropogenic streambank erosion, and non-system roads.

Unpaved roads accounted for the greatest percentage (43%) of anthropogenic sediment production in Spring Creek. Road crossings throughout watershed, and direct road tread drainage in the central watershed are contributing to road related sediment impacts. Timber harvest has occurred in the upper watershed, some of which was related to post fire salvage activities. Four abandoned mines (Bluebird, Corbin Flats, Washington, and Salvai) within Spring Creek were identified as being capable of delivering sediment to the channel. The occurrence of anthropogenic streambank erosion is isolated throughout Spring Creek, and largely a result of stream channelization and historic mining activity. Non-system roads/trails were observed in the uplands of the Spring Creek watershed. The lack of drainage structures on these roads can lead to disproportionately large volumes of sediment being generated from this source.

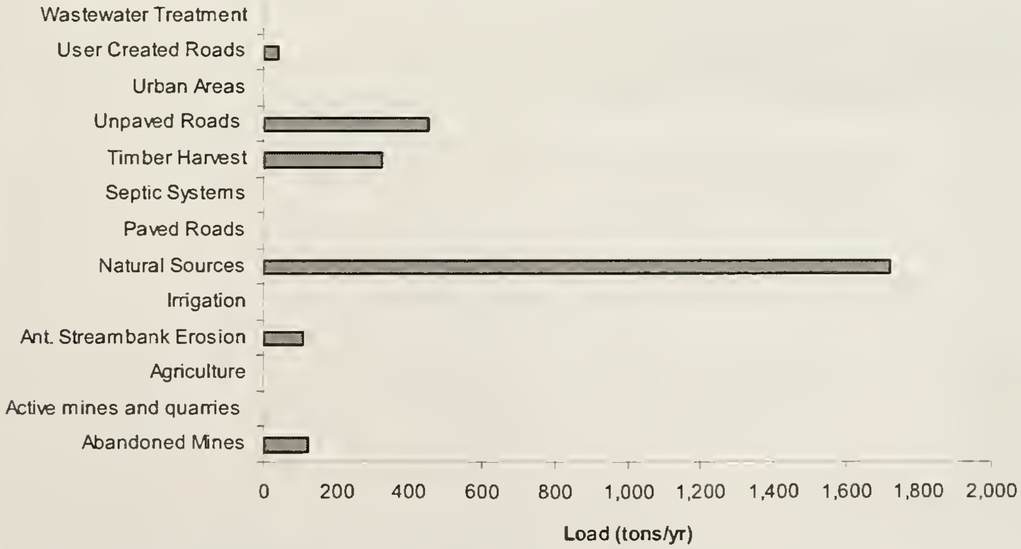

Figure 12-8. Total annual sediment load from all potentially significant sources in the Spring Creek Watershed.

12.3.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

12.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 12-9. Based on the results of the source assessment (Section 12.3.1), the recommended implementation strategy to address the sediment problem in Spring Creek is to reduce sediment loading from the primary anthropogenic sediment sources – unpaved roads, timber harvest, abandoned mines, anthropogenic streambank erosion, and non-system roads. As shown in Table 12-9, the hypothesis is that an overall, watershed scale sediment load reduction of 30 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current unpaved roads, timber harvest, abandoned mines, anthropogenic streambank erosion, and non-system roads by 60, 97, 79, 99, and 100 percent, respectively.

Table 12-9. TMDL, Allocations, and Margin of Safety for Spring Creek – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	121	67	40	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 67%.	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	112	97	3	It is estimated that there are 4.4 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	40	100	0	All non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads. Therefore, this load reduction may be an overestimate.
	Timber Harvest	326	97	10	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	454	60	182	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	1,053	78	235		
	Natural Sources	1,719	0	1,719	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Spring Creek Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**2,772**	**30**	**1,954**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 235 lbs/yr + 1,719 lbs/yr + 0 = 1,954 lbs/yr** **TMDL = 0 + 0.6 lbs/day + 4.7 lbs/day + 0 = 5.3 lbs/day**					

13.0 TENMILE CREEK

Three segments of Tenmile Creek have appeared on various Montana 303(d) lists: Tenmile Creek from Headwaters to Helena Public Water Supply Intake upstream of Rimini (MT41I006_141), Tenmile Creek from Helena Public Water Supply Intake upstream of Rimini to Helena Water Treatment Plant (MT41I006_142), and Tenmile Creek from Helena Water Treatment Plant to the Mouth (MT41I006_143). Impaired uses and causes of impairment varied by segment and by 303(d) list.

Volume I of the Lake Helena Report presented additional data and analyses for the 303(d) listed segments in Tenmile Creek. Using a weight of evidence approach, the impairment status of each segment was updated.

The following paragraphs summarize the 303(d) listings and Volume I analyses for Tenmile Creek:

- **Tenmile Creek from Headwaters to Helena Public Water Supply Intake upstream of Rimini (MT41I006_141)** – In 1996, the coldwater fishery drinking water, and aquatic life beneficial uses in the 6.0-mile segment of Tenmile Creek were listed as impaired because of siltation, pH, and metals. In 2002 and 2004, aquatic life, coldwater fishery, and drinking water supply beneficial uses were listed as impaired because of arsenic, cadmium, copper, lead, mercury, metals, siltation, and zinc. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, copper, lead, and zinc are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.2.1 of the Volume I Report). Siltation and pH are not impairing beneficial uses, and therefore no TMDLs will be presented. There were insufficient data to determine if mercury is impairing beneficial uses.

- **Tenmile Creek from Helena Public Water Supply Intake upstream of Rimini to Helena Water Treatment Plant (MT41I006_142)** – In 1996, the coldwater fishery drinking water, and aquatic life beneficial uses in the 7.7-mile segment of Tenmile Creek were listed as impaired because of siltation, pH, and metals. In 2002 and 2004, aquatic life, coldwater fishery, and drinking water supply beneficial uses were listed as impaired because of arsenic, cadmium, copper, lead, metals, siltation, and zinc. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, copper, lead, zinc, and sediment are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.2.2 of the Volume I Report). pH is not impairing beneficial uses, and therefore no TMDL will be presented.

- **Tenmile Creek from Helena Water Treatment Plant to the Mouth (MT41I006_143)** – In 1996, the coldwater fishery drinking water, and aquatic life beneficial uses in the 15.9-mile segment of Tenmile Creek were listed as impaired because of siltation, pH, and metals. In 2002 and 2004, aquatic life, coldwater fishery, and drinking water supply beneficial uses were listed as impaired because of arsenic, cadmium, copper, lead, mercury, metals, nutrients, siltation, zinc. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, copper, lead, zinc, nutrients, and sediment are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.2.3 of the Volume I Report). pH is not impairing beneficial uses, and therefore no TMDLs will be presented. There were insufficient data to determine if mercury is impairing beneficial uses.

Conceptual restoration strategies and the required TMDL elements for nutrients, sediment, and metals (i.e., arsenic, cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix C, D, E, and F.

13.1 METALS

The available water chemistry data suggest that Tenmile Creek is impaired by arsenic, cadmium, copper, lead, and zinc (See Volume I Report). TMDLs are presented in the following sections to address the metals impairments. The metals TMDLs are presented at the scale of the entire Tenmile Creek watershed. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

13.1.1 Sources of Metals in the Tenmile Creek Watershed

Tenmile Creek from Headwaters to Helena Public Water Supply Intake upstream of Rimini (MT41I006_141) - Relevant sources of metals to the stream segment are historical hard rock mining activities in the immediate drainage area. The drainage area of this segment of the stream falls within the Rimini mining district. The MBMG Abandoned and Inactive Mines database shows mineral location, placer, surface, surface-underground, underground, and other unknown mining activities in the drainage area of the stream. The historical mining types include lode, mill, and placer. In the past these mines produced gold, silver, lead, copper, manganese, zinc, and arsenic. Of the more than 20 mines present in the headwaters area, 12 are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites: Valley Forge/Susie, Red Water, Red Mountain, Tenmile Mine, National Extension, Monte Cristo, Se Se S13, Queensbury, Peerless Jenny/King, Monitor Creek Tailings, Peter, and Woodrow Wilson. The Helena National Forest documented placer tailings and historical mining dams during the source assessment.

Tenmile Creek from Helena Public Water Supply Intake upstream of Rimini to Helena Water Treatment Plant (MT41I006_142) - Relevant sources of metals in this stream segment include adjacent abandoned mines and pollutant inputs from the stream's headwaters area (Tenmile Creek 141). The immediate drainage area falls within the Rimini mining district. The MBMG Abandoned and Inactive Mines database reports mineral location, underground, and other, "unknown" mining activities in the drainage area of the stream. The historical mining types include lode and placer. In the past these mines produced gold, silver, lead, and zinc. Four mines are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites: Bear Gulch, Upper Valley Forge, Beatrice, and Armstrong Mine.

Tenmile Creek from Helena Water Treatment Plant to the Mouth (MT41I006_143) - Relevant sources of metals to the stream segment are upstream sources and historical mining activities in the immediate drainage area. The segment's upstream reach (Tenmile Creek 142) also contributes metals. The immediate drainage area falls within the Blue Cloud, Helena, and Scratchgravel Hills mining districts. The MBMG Abandoned and Inactive Mines database reports hot springs, mineral location, placer, surface, surface-underground, underground, and other unknown mining activities in the immediate drainage area of the stream. The historical mining types include lode, mill, and placer. In the past these mines produced gold, silver, copper, lead, uranium, arsenic, and zinc. Six mines are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites: Franklin (Scratchgravel), Joslyn Street Tailings (Helena district) , Lower Tenmile Mine (Rimini), Davis Gulch II (Helena), Spring Hill Tailings (Helena), and Lady Luck (Helena).

Modeled sources and their metals loadings to Tenmile Creek are presented in Figure 13-1 through Figure 13-5. The Upper Tenmile Creek Superfund Mining Area and all other abandoned hard rock mine sites in the Tenmile Creek watershed are included within the source category "Abandoned Mines", which represents the most significant source of all metals.

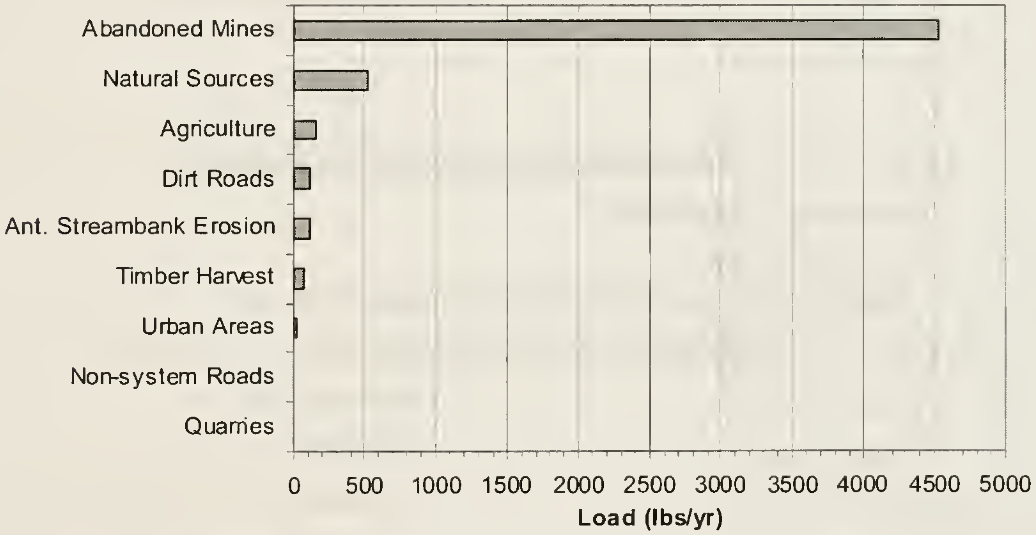

Figure 13-1. Sources of arsenic loadings to Tenmile Creek.

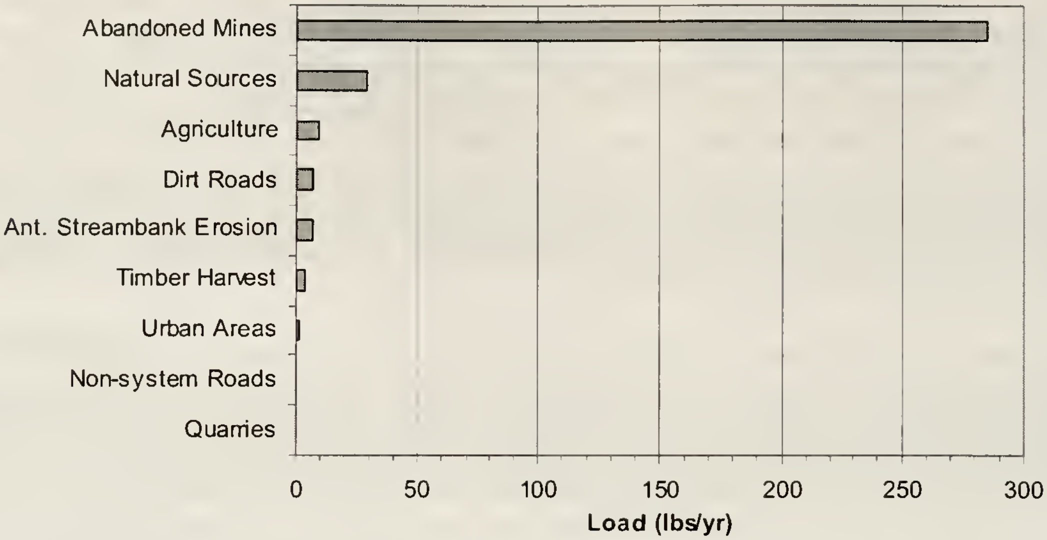

Figure 13-2. Sources of cadmium loadings to Tenmile Creek.

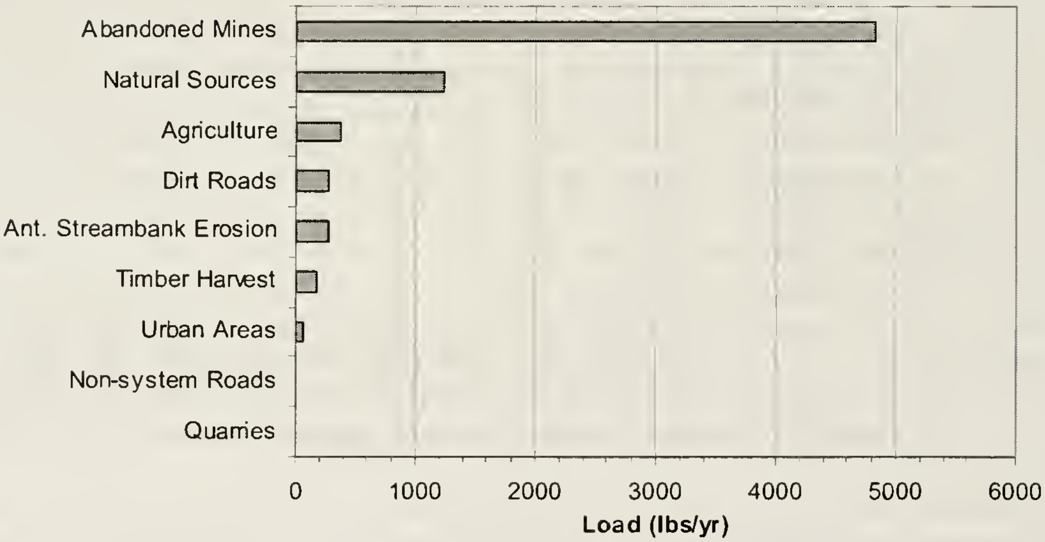

Figure 13-3. Sources of copper loadings to Tenmile Creek.

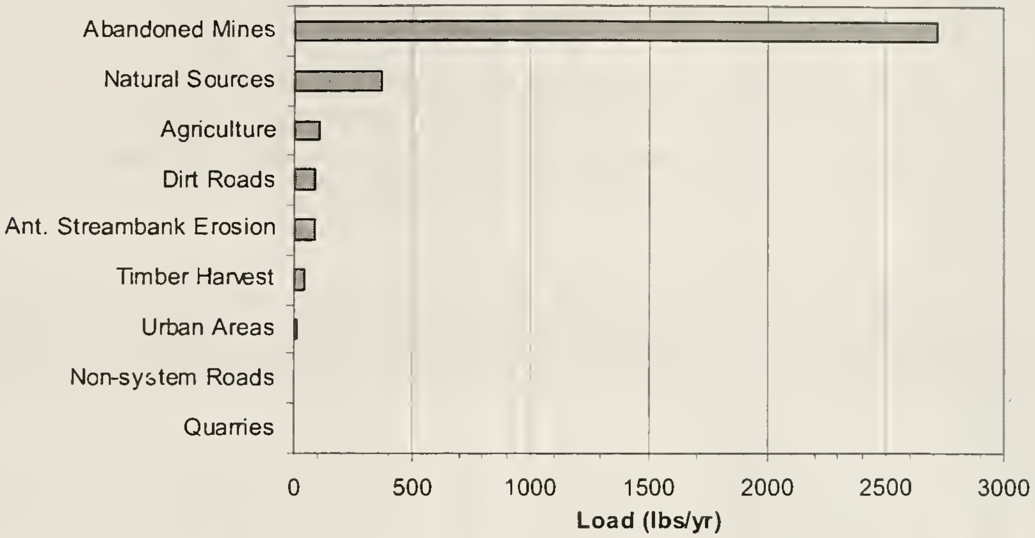

Figure 13-4. Sources of lead loadings to Tenmile Creek.

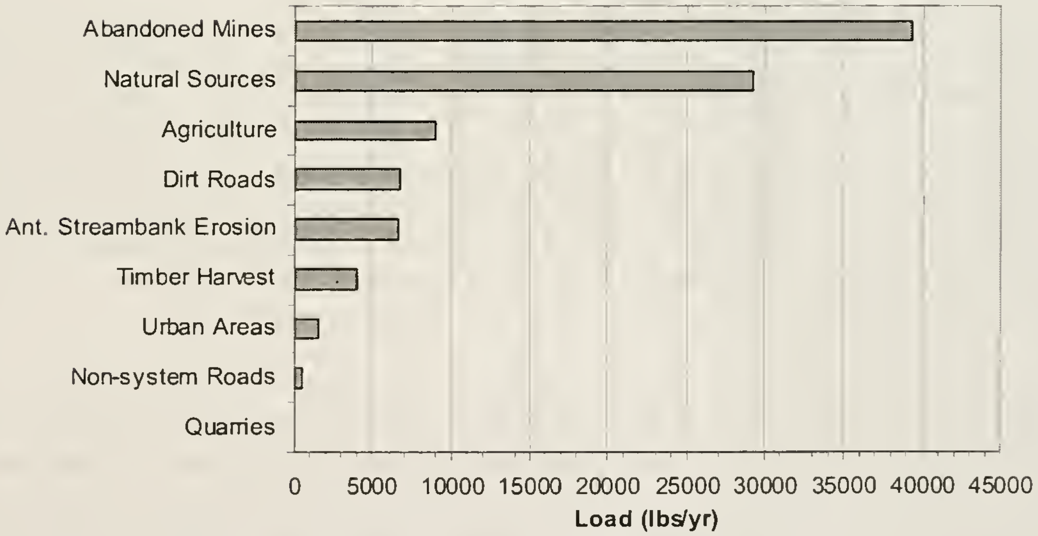

Figure 13-5. Sources of zinc loadings to Tenmile Creek.

13.1.2 Water Quality Goals/Targets

The ultimate goal of the TMDLs for metals is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in Tenmile Creek are presented in Table 13-1.

Table 13-1. Montana numeric surface water quality standards for metals in Tenmile Creek.

Parameter	Aquatic Life (acute) (μg/L)[a]	Aquatic Life (chronic) (μg/L)[b]	Human Health (μg/L)[a]
Arsenic (TR)	340	150	10 [d]
Cadmium (TR)	2.3 at 106.5 mg/L hardness[c]	0.3 at 106.5 mg/L hardness[c]	5
Copper (TR)	14.7 at 106.5 mg/L hardness[c]	9.7 at 106.5 mg/L hardness[c]	1,300
Lead (TR)	87.2 at 106.5 mg/L hardness[c]	3.4 at 106.5 mg/L hardness[c]	15
Zinc (TR)	127.5 at 106.5 mg/L hardness[c]	127.5 at 106.5 mg/L hardness[c]	2,000

Note: TR = total recoverable.

[a] Maximum allowable concentration.

[b] No 4-day (96-hour) or longer period average concentration may exceed these values.

[c] The standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).

[d] The human health standard for arsenic is currently 18 μg/L, but will change to 10 μg/L in 2006.

13.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Figure 13-2 through Table 13-6. Based on the results of the source assessment (Section 13.1.1), the recommended implementation strategy to address the metals problem in Tenmile Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs. As shown in Figure 13-2 through Table 13-6, the hypothesis is that an overall, watershed scale metals load reduction of 66, 80, 69, 79, and 55 percent for arsenic, cadmium, copper, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from mining sources by 72, 89, 84, 89, and 77 percent for arsenic, cadmium, copper, lead, and zinc, respectively.

It should be noted that EPA developed a site-specific WASP modeling analysis of Upper Tenmile Creek as part of the ongoing Superfund efforts. This model was subsequently used to identify load reductions necessary to meet water quality standards under steady-state flow conditions (Caruso, 2004). The LSPC model was developed to complement the WASP model for three primary reasons: (1) to evaluate water quality standards under all flow conditions (not just low flows); (2) to evaluate the impact of upstream Tenmile Creek reductions on conditions downstream of the WASP model boundary; and (3) to provide a consistent modeling platform throughout the Lake Helena watershed. The findings from the WASP-modeling analysis are similar to those presented here (i.e., load reductions in the range of 60 to 80 percent are required to meet all water quality standards).

Table 13-2. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	4,530.7	72	1,284.9	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	162.1	80	33.1	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	118.5	90	11.7	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 90%, thereby reducing sediment associated metals loads from streambank erosion by 90%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	9.3	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	0.8	0	0.8	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	71.6	97	2.1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	120.8	60	48.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	26.7	80	5.4	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	5,040.5	72	1,386.3	▨	▨
	Natural Sources	526.3	0	526.3	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Tenmile Creek Watershed.	
Margin of Safety	▨	NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	▨
Total	▨	**5,566.8**	**66**	**1,912.6**	▨	▨
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 1,386.3 lbs/yr + 526.3 lbs/yr + 0 = 1,912.6 lbs/yr** **TMDL = 0 + 3.8 lbs/day + 1.4 lbs/day + 0 = 5.2 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 13-3. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	285.2	89	32.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	9.1	80	1.9	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	6.7	90	0.7	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 90%, thereby reducing sediment associated metals loads from streambank erosion by 90%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.5	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	0.0	0	0.0	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	4.0	97	0.1	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	6.8	60	2.7	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1.5	80	0.3	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	313.8	88	38.0		
	Natural Sources	29.6	0	29.6	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**343.4**	**80**	**67.6**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 38.0 lbs/yr + 29.6 lbs/yr + 0 = 67.6 lbs/yr** **TMDL = 0 + 0.10 lbs/day + 0.08 lbs/day + 0 = 0.18 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 13-4. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Copper.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	4,822.0	84	762.7	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	379.5	80	77.4	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	277.4	90	27.3	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 90%, thereby reducing sediment associated metals loads from streambank erosion by 90%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	21.7	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	1.9	0	1.9	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	167.7	97	5.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	282.9	60	113.2	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	62.4	80	12.7	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	6,015.5	83	1,000.2		
	Natural Sources	1,232.2	0	1,232.2	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of copper in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**7,247.7**	**69**	**2,232.4**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 1,000.2 lbs/yr + 1,232.2 lbs/yr + 0 = 2,232.4 lbs/yr** **TMDL = 0 + 2.7 lbs/day + 3.4 lbs/day + 0 = 6.1 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 13-5. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	2,714.9	89	295.7	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	113.2	80	23.1	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	82.7	90	8.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 90%, thereby reducing sediment associated metals loads from streambank erosion by 90%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	6.5	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	0.6	0	0.6	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	50.0	97	1.5	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	84.4	60	33.7	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	18.6	80	3.8	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	3,070.9	88	366.6		
	Natural Sources	367.5	0	367.5	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**3,438.4**	**79**	**734.1**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 366.6 lbs/yr + 367.5 lbs/yr + 0 = 734.1 lbs/yr** **TMDL = 0 + 1.0 lbs/day + 1.0 lbs/day + 0 = 2.0 lbs/day**					

[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

Table 13-6. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	39,384.8	77	8,889.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	8,989.2	80	1,834.2	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in metals loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached metals loading.[1]	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	6,570.4	90	647.4	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 90%, thereby reducing sediment associated metals loads from streambank erosion by 90%.[1]	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	513.7	100	0.0	Ideally all non-system roads should be closed and reclaimed. Sediment loads from non-system roads will be reduced by 100%, thereby reducing sediment associated metals loads from non-system roads by 100%.[1]	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	44.0	0	44.0	Only the land draining offsite is assumed to generate metals loading. No BMPs are assumed for active quarries, though reclamation should be required upon closure.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	3,972.9	97	119.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.[1]	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	6,701.5	60	2,680.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60%.[1]	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	1,479.1	80	301.0	It is assumed that urban BMPs will reduce sediment loads by 80%, thereby reducing sediment associated metals loads from urban areas by 80%.[1]	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	67,655.6	78	14,515.7		
	Natural Sources	29,189.1	0	29,189.1	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of zinc in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total		**96,844.7**	55	**43,706.0**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 14,515.7 lbs/yr + 29,189.1 lbs/yr + 0 = 43,706.0 lbs/yr** **TMDL = 0 + 39.7 lbs/day + 80.0 lbs/day + 0 = 119.7 lbs/day**					

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[1] The assumption that there is a one-to-one relationship between sediment and metals removal may result in an overestimate of the load reductions. Metals removal is generally less than solids removal, both because there is a dissolved phase and because of preferential sorption to fines. The difference depends on source type and local water chemistry. Therefore, the reported percent reductions are likely greater than that which will occur in the field.

13.2 NUTRIENTS

The weight-of-evidence suggest that Tenmile Creek is impaired by nutrients (See Volume I Report). TMDLs are presented in the following sections to address the nutrient impairments. The nutrient TMDLs are presented at the scale of the entire Tenmile Creek watershed and the loading analyses presented in this section are based on application of the GWLF model (see Appendix C). In the absence of a strong case for either N or P limitation in the ultimate receiving water bodies (i.e., Prickly Pear Creek and Lake Helena), TMDLs are presented below for both nitrogen and phosphorus.

13.2.1 Nitrogen

13.2.1.1 Sources of Nitrogen in the Tenmile Creek Watershed

As shown in Figure 13-6, based on the watershed scale modeling analysis (See Appendix C), the primary anthropogenic sources of nitrogen in the Tenmile Creek watershed, in order of importance include septic systems, urban areas, agriculture, anthropogenic streambank erosion, timber harvest and paved roads. Additionally, dewatering has affected the natural hydrology of the stream and the quality of aquatic habitat. Diffuse sediment and possibly nutrients sources from rural housing and subdivisions also affect the stream.

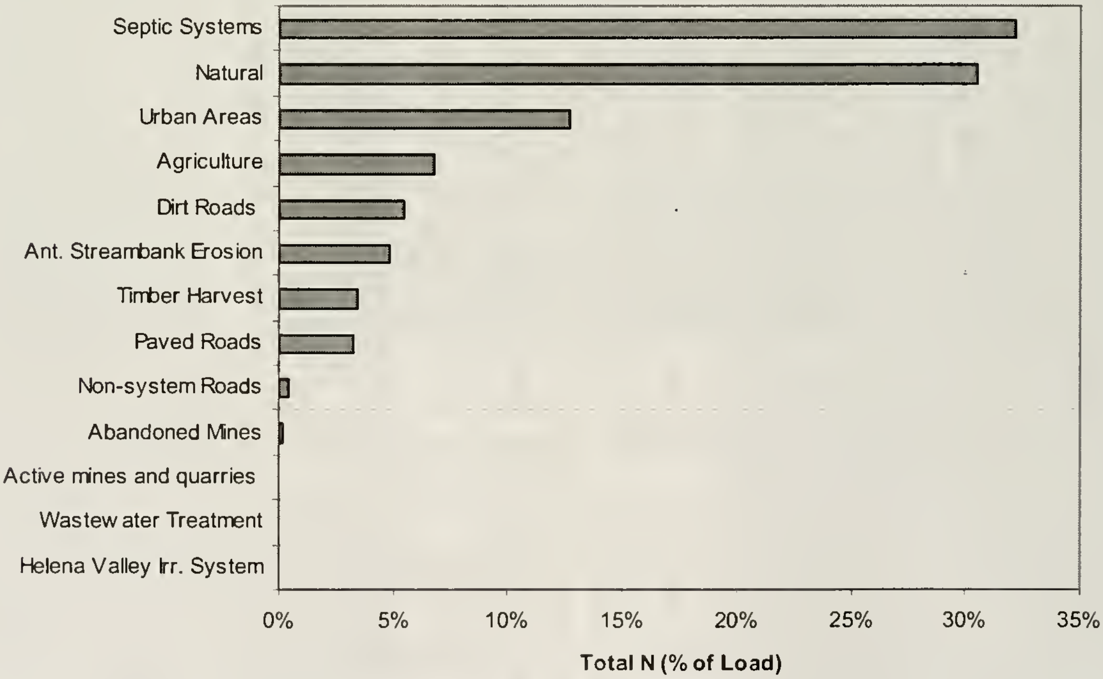

Figure 13-6. Percent of the annual TN load from all potentially significant sources in the Tenmile Creek Watershed.

13.2.1.2 Water Quality Goals/Targets

The proposed interim water quality target for total nitrogen in Tenmile Creek is 0.33 mg/L. A strategy to revise this interim target in the future is presented in Volume II, Section 3.2.3.

13.2.1.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the nitrogen TMDL is to attain full beneficial use support in Tenmile Creek. In the absence of better data/information, the interim target presented in Section 13.2.1.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 59 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable nitrogen load reduction for the Tenmile Creek Watershed is estimated to be only 23 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Tenmile Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TN load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TN target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 13-7. The adaptive management strategy is presented in Volume II, Section 3.2.3.1

Alternative Load Reduction Strategies

It should also be noted that alternative remedies could be used to meet the in-stream nutrient targets. For example, one restoration strategy under consideration for the Upper Tenmile Creek metals impairments is to bypass water through the City of Helena's Rimini diversion into Tenmile Creek. The bypass would result in less water being diverted by the city for water supply and would increase the minimum flow, essentially helping to dilute both metals and nutrient concentrations.

Table 13-7. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Nitrogen.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.11	79	0.02	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 79%. Sediment-associated nitrogen will decrease accordingly (79%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated nitrogen reductions could be over or under estimated.
	Agriculture	3.87	79	0.81	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading.	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	2.76	90	0.28	It is estimated that there are 9.9 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.26	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	1.83	30	1.28	An average nitrogen removal efficiency of 30% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	18.51	0.5	18.42	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake. Replacing those systems with conventional level 1 treatment results in a 0.5% decrease in TN. Replacing failing septic systems with level 2 treatment could result in a 1.7% reduction in TN.	The number of septic systems is estimated based on well locations. The number of septic systems may be over or under estimated.
	Timber Harvest	1.98	97	0.06	It is assumed that nitrogen loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, nitrogen reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	3.12	60	1.25	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding nitrogen load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	7.23	30	5.06	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average nitrogen removal efficiency of 30% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	39.67	33	27.18		
	Natural Sources	17.29	0	17.29	It is assumed that the nitrogen loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	Basin Creek Mining (MT0028690), the City of Helena Tenmile Water Treatment Plant (MT0028720), and Pacific Steel and Recycling (storm water) (MTR000430) all have no discharge data available and are likely insignificant sources of nitrogen. Therefore, the WLA is set to zero.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**56.96**	**23**	**44.47**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 27.18 tons/yr + 17.29 tons/yr + 0 = 44.47 tons/yr** **TMDL = 0 + 0.07 tons/day + 0.05 tons/day + 0 = 0.12 tons/day**					

13.2.2 Phosphorus

13.2.2.1 Sources of Phosphorus in the Tenmile Creek Watershed

As shown in Figure 13-7, the primary anthropogenic sources of phosphorus in the Tenmile Creek watershed, in order of importance, are agriculture, urban areas, dirt roads, anthropogenic streambank erosion, timber harvest and paved roads. Additionally, dewatering has affected the natural hydrology of the stream and the quality of aquatic habitat. Diffuse sediment and possibly nutrients sources from rural housing and subdivisions also affect the stream.

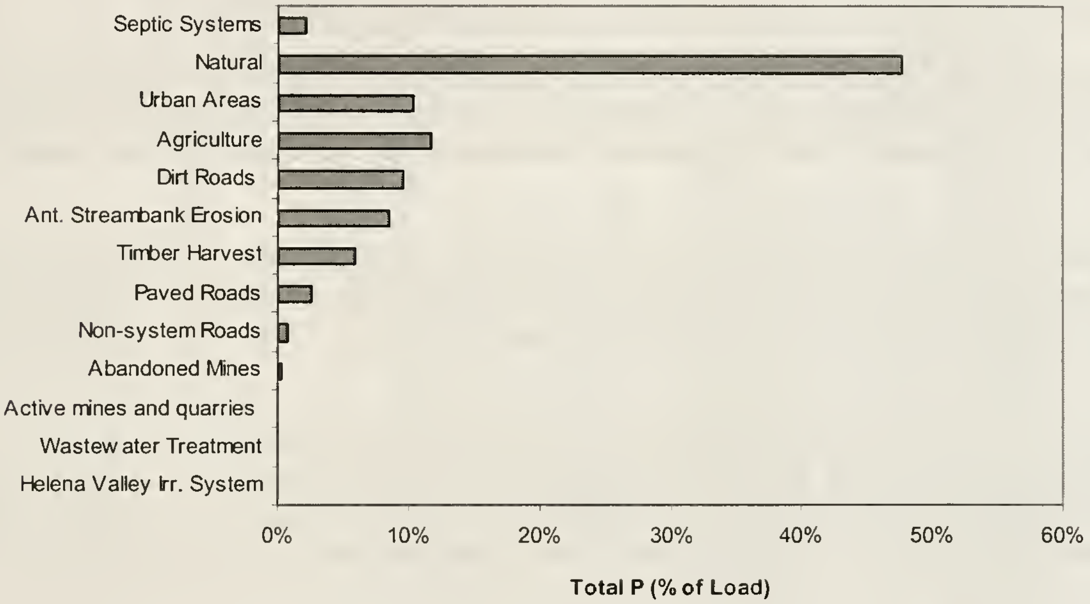

Figure 13-7. Percent of the annual TP load from all potentially significant sources in the Spring Creek Watershed.

13.2.2.2 Water Quality Goals/Targets

The proposed water quality target for total phosphorus in Tenmile Creek is 0.04 mg/L (See Volume I Section 3.2.3). A strategy to revise this target, if deemed appropriate, is presented in Section 3.2.3 of the main report.

13.2.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The goal of the phosphorus TMDL is to attain full beneficial use support in Tenmile Creek. In the absence of better data/information, the interim target presented in Section 13.2.2.2 is assumed to represent the nitrogen level below which all beneficial uses would be supported. A nitrogen load reduction of 61 percent would be required to attain this target.

Based on a modeling analysis where it was conservatively assumed that BMPs would be applied to all non-point sources, the maximum attainable TP load reduction for the Tenmile Creek Watershed is estimated to be only 38 percent, indicating that it may not be possible to attain the target.

The proposed approach, therefore, acknowledges that it may not be possible to attain the target, but also acknowledges the fact that current nutrient levels are impairing beneficial uses and water quality in Tenmile Creek and downstream receiving water bodies will continue to degrade if no action is taken to reduce loading.

The proposed approach seeks the maximum attainable TP load reductions from non-point sources, and, in recognition of the fact that it may not be possible to attain the TP target, presents an adaptive management strategy for revising the target and load allocations in the future. The proposed approach is embodied in the TMDL, allocations and margin of safety presented in Table 13-8. The adaptive management strategy is presented in Volume II, Section 3.2.3.1

Table 13-8. TMDL, Allocations, and Margin of Safety for Tenmile Creek –Phosphorus.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	0.02	79	0	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 79%. Sediment-associated phosphorus will decrease accordingly (79%).	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, sediment-associated phosphorus reductions could be over or under estimated.
	Agriculture	0.84	79	0.18	Loading estimates for this source category assume that no BMPs have been applied The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment with corresponding decreases in nutrient loading) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing soil attached nutrient loading	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Anthropogenic Streambank Erosion	0.61	90	0.06	It is estimated that there are 16.2 miles of eroding stream banks in the watershed caused by a variety of human activities. It is assumed that bank erosion will be returned to reference levels based on BEHI values.	The watershed scale estimates of stream bank erosion are based on extrapolation from field surveys conducted on representative main-stem reaches. This likely overestimates the total amount of bank erosion. Also, due to access constraints and physical constraints, it may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.06	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Paved Roads	0.18	50	0.09	An average phosphorus removal efficiency of 50% is assumed based on the literature for urban areas (CWP, 2000).	Current loads from paved roads are based on public agency data and literature values for runoff concentrations. The current loads may be over or underestimated.
	Septic Systems	0.16	100	0	It is assumed that 7% of septic systems in the watershed are failing (see Appendix C), and effluent from the failing systems bypasses both drainfield treatment and plant uptake Replacing those systems with conventional level 1 treatment results in a 100% decrease in TP.	The number of septic systems is estimated based on well locations The number of septic systems may be over or under estimated
	Timber Harvest	0.42	97	0.01	It is assumed that phosphorus loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery. Based on watershed modeling results, phosphorus reductions are estimated to be 97%.	Current loads from timber harvest are based on public agency data and course assumptions regarding private forestland. Thus the current timber harvest load from private lands may be over or underestimated
	Unpaved Roads	0.69	60	0.28	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding phosphorus load reduction of 60% (See Appendix C).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	0.73	50	0.37	The effectiveness of urban storm water BMPs has been well studied It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average phosphorus removal efficiency of 50% is assumed (CWP, 2000).	Given existing infrastructure, and therefore the need to retrofit storm water BMPs into the landscape, it may not be possible or practical to fully implement storm water BMPs in all areas. Therefore, this load reduction is likely an overestimate.
	Total – All Anthropogenic Nonpoint Sources	3.71	73	0.99		
	Natural Sources	3.40	0	3.40	It is assumed that the phosphorus loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled
Wasteload Allocation	**All Point Sources**	0	NA	0	Basin Creek Mining (MT0028690), the City of Helena Tenmile Water Treatment Plant (MT0028720), and Pacific Steel and Recycling (storm water) (MTR000430) all have no discharge data available and are likely insignificant sources of phosphorus. Therefore, the WLA is set to zero	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		7.11	38	4.39		
TMDL	**TMDL = WLA + LA + Natural + MOS TMDL = 0 + 0.99 tons/yr + 3.4 tons/yr + 0 = 4.39 tons/yr TMDL = 0 + 0.003 tons/day + 0.009 tons/day + 0 = 0.012 tons/day**					

13.3 SEDIMENT

Based on the weight of evidence, the cold-water fishery and aquatic life beneficial uses in Tenmile Creek are impaired by siltation. TMDLs are presented in the following sections to address the sediment impairments. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

13.3.1 Sources of Sediment in the Tenmile Creek Watershed

As shown in Figure 13-8, the primary anthropogenic sources of sediment in the Tenmile Creek watershed, in order of sediment load are agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads/trails, abandoned mines, and active mines and quarries.

Agriculture was the single greatest sediment source within the greater Tenmile Creek watershed, representing 30 percent of the total anthropogenic sediment load. As a land-use, agriculture occurs in the lower elevation areas of the watershed including middle and lower Tenmile Creek, and Sevenmile Creek watersheds. Unpaved roads were the second greatest anthropogenic sediment source, accounting for 24 percent of this load. The majority of the road sediment was generated in high road density watersheds such as upper and lower Tenmile and Sevenmile Creeks. Segments within the greater Tenmile watershed that generate large streambank erosion sediment load include middle and lower Tenmile, and Sevenmile watersheds. Causes of streambank erosion in these watersheds are riparian grazing, road encroachment, stream channelization, riparian vegetation removal, and historic mining activity. Most of the sediment related to timber harvest activities is generated in upper Tenmile Creek, with lesser quantities from middle Tenmile and Skelly Gulch. Sediment from urban areas is largely generated within the middle and lower Tenmile watersheds, and is associated with the rapid development of the Helena Valley. Non-system roads/trails occur throughout the greater watershed, but have higher densities in the public land areas of the upper watershed. Ten abandoned mines (Armstrong, Beatrice, Monitor Creek, National Extension, Peter, Red Mountain, Red Water, Upper Valley Forge, Valley Forge/Susie, and Woodrow Wilson) within Warm Spring Creek were identified as likely delivering sediment to a channel within the Tenmile watershed. All of the mines are located within the upper and middle Tenmile Creek watersheds. None of the mines have been formally reclaimed and thus continue to generate sediment. Sediment from active mines and quarries is solely generated in lower Tenmile Creek and is related to gravel quarries in the western Helena Valley.

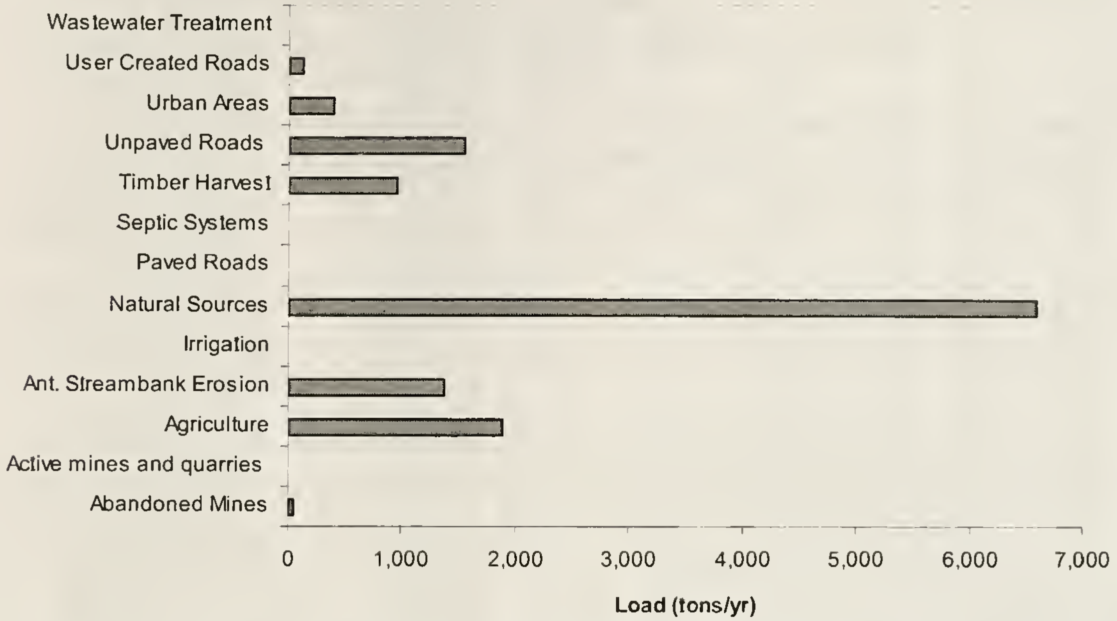

Figure 13-8. Total annual sediment load from all potentially significant sources in the Tenmile Creek Watershed.

13.3.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume I, Section 3.1.3.

13.3.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 13-9. Based on the results of the source assessment (Section 13.3.1), the recommended implementation strategy to address the sediment problem in Tenmile Creek is to reduce sediment loading from the primary anthropogenic sediment sources – agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads, abandoned mines, and active mines and quarries. As shown in Table 13-9, the hypothesis is that an overall, watershed scale sediment load reduction of 36 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current agricultural, unpaved roads, anthropogenic streambank erosion, timber harvest, urban areas, non-system roads, and abandoned mines by 60, 60, 90, 97, 80, 100, and 79 percent, respectively.

Table 13-9. TMDL, Allocations, and Margin of Safety for Tenmile Creek – Siltation.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	55	79	12	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 79%.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Agriculture	1,895	60	758	Loading estimates for this source category assume that no BMPs have been applied. The load reduction approach assumes vegetative buffers will be employed (50% removal efficiency for sediment) plus alternative crop management practices that will minimize the area of bare soil, thereby reducing erosion.	The assumption that no agricultural fields currently have BMPs may be incorrect. Thus the existing load may be overestimated.
	Anthropogenic Streambank Erosion	1,380	90	138	It is estimated that there are 16.2 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	129	100	0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Quarries	10	0	10	Loading estimates reflect no reduction in load allocation. This is due to the small load size relative to other sediment sources.	Drainage patterns for quarries were assessed with aerial photography and may not accurately depict actual site hydrology.
	Timber Harvest	957	97	29	It is assumed that sediment loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	1,558	60	623	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban Areas	393	80	79	The effectiveness of urban storm water BMPs has been well studied. It is assumed that a combination of BMPs will be employed ranging from proper use of lawn fertilizers to vegetated buffer strips and engineered detention facilities, etc. Based on the literature, an average sediment removal efficiency of 80% is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	6,377	74	1,649		
	Natural Sources	6,598	0	6,598	It is assumed that the sediment loads from all other source categories are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Tenmile Creek Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total		**12,975**	**36**	**8,247**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 1,649 lbs/yr + 6,598 lbs/yr + 0 = 8,247 lbs/yr** **TMDL = 0 + 4.5 lbs/day + 18.1 lbs/day + 0 = 22.6 lbs/day**					

14.0 WARM SPRINGS CREEK, MIDDLE FORK WARM SPRINGS CREEK, AND NORTH FORK WARM SPRINGS CREEK

Three segments in the Warm Springs Creek watershed have appeared on various Montana 303(d) lists: Middle Fork Warm Springs Creek (MT41I006_100), North Fork Warm Springs Creek (MT41I006_180), and Warm Springs Creek (MT41I006_110). Impaired uses and causes of impairment varied by segment and by 303(d) list.

Volume I of the Lake Helena Report presented additional data and analyses for the 303(d) listed segments in Warm Springs Creek. Using a weight of evidence approach, the impairment status of each segment was updated.

The following paragraphs summarize the 303(d) listings and Volume I analyses for Warm Springs Creek, North Fork Warm Springs Creek, and Middle Fork Warm Springs Creek:

- **Middle Fork Warm Springs Creek from the headwaters to the mouth (MT41I006_100)** – In 1996, the cold-water fishery and aquatic life beneficial uses in the 2.7-mile segment of Middle Fork Warm Springs Creek were listed as partially supported because of siltation and metals. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of arsenic, copper, mercury, metals, siltation, and zinc. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, lead, zinc, and sediment are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.9 of the Volume I Report). Copper is not impairing beneficial uses, and therefore no TMDL will be presented. There were insufficient data to determine if mercury is impairing beneficial uses.

- **North Fork Warm Springs Creek from the headwaters to the mouth (MT41I006_180)** – North Fork Warm Springs Creek was added to the Montana 303(d) list in 1998. The 3.5-mile segment was listed as partially supporting aquatic life and cold-water fishery beneficial uses because of siltation. In 2002 and 2004, aquatic life, cold-water fishery, and drinking water supply beneficial uses were listed as impaired because of arsenic, metals, organic enrichment/low DO, and siltation. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, zinc, and sediment are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.10 of the Volume I Report). Nutrients (i.e., organic enrichment/low DO) are not impairing beneficial uses, and therefore no TMDL will be presented.

- **Warm Springs Creek from the headwaters to the mouth (MT41I006_110)** – In 1996, the cold-water fishery and aquatic life beneficial uses in the 8.8-mile segment of Warm Springs Creek were listed as partially supported because of suspended solids and metals. In 2002 and 2004, aquatic life and cold-water fishery beneficial uses were listed as impaired because of siltation. The additional analyses and evaluations described in Volume I found that arsenic, cadmium, lead, zinc, and sediment (suspended solids and siltation) are currently impairing aquatic life, fishery, and drinking water beneficial uses (see Section 3.4.1.11 of the Volume I Report).

Conceptual restoration strategies and the required TMDL elements for sediment and metals (i.e., arsenic, cadmium, copper, lead, and zinc) are presented in the following subsections. Supporting information for the following TMDLs can also be found in Appendix D, E, and F.

14.1 METALS

The available water chemistry data suggest that Tenmile Creek is impaired by arsenic, cadmium, lead, and zinc (See Volume I Report). TMDLs are presented in the following sections to address the metals impairments. The loading analyses presented in this section are based on application of the LSPC model (see Appendix F).

14.1.1 Sources of Metals in the Warm Springs Creek Watershed

Middle Fork Warm Springs Creek (MT41I006_100) - Historical hard rock mining activities in the sub-watershed comprise the most significant sources of metals loading. The headwaters of the creek fall within the McClellan mining district while the rest is within the Alhambra mining district. The MBMG Abandoned and Inactive Mines database reports surface, underground, mineral location, and prospect mining activities in the watershed. The historical mining types include placer, lode, and mill. In the past these mines produced gold, silver, lead, and copper. Two of the mines in the upstream section of the sub-watershed, Middle Fork Warm Springs (Alhambra district) and Solar Silver (Warm Springs district), are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites and are slated for cleanup. The state's inventory shows 12 other mines in this watershed. A large tailings mine dump, observed in the middle of the stream during source assessment visits to the watershed, prevented vegetation growth and disrupted the natural channel. Water in upper Middle Fork of Warm Springs Creek had a metallic sheen that might have been associated with the presence of metals ions.

North Fork Warm Springs Creek (MT41I006_180) - Historical mining activities in the watershed in the sub-watershed comprise the most significant sources of metals loading. The majority of the watershed falls within the Alhambra mining district. The MBMG Abandoned and Inactive Mines database reports underground mining activities in the watershed. The historical mining types include lode mining. In the past these mines produced gold, silver, lead, and copper. The state's inventory of mines shows two hard rock mines close to the headwaters and one mine close to the mouth of the stream. None of the mines in the basin are listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites.

Warm Springs Creek (MT41I006_110) - Relevant sources of metals in this stream segment include tributaries, possible natural hot springs, and historical mining activities in the immediate drainage area. The tributaries, the North Fork and Middle Fork of Warm Springs, are significant contributors of metals. The immediate drainage area of this stream falls within the Alhambra mining district. The MBMG Abandoned and Inactive Mines database shows hot spring, mineral location, and underground mining activities in the drainage area of the stream. The historical mining types include lode and placer mining. In the past these mines produced gold, silver, lead, copper, and zinc. The Alhambra Hot Springs Mine is listed in the State of Montana's inventory of High Priority Abandoned Hardrock Mine Sites.

Modeled sources and representing metals loadings to all segments of Warm Springs Creek are presented in Figure 14-1 through Figure 14-4.

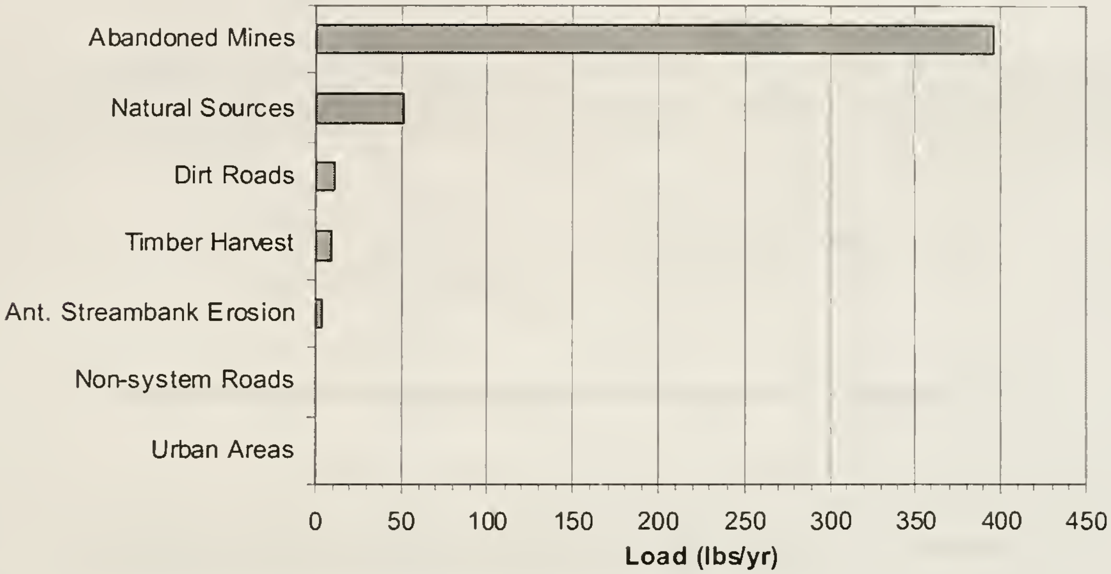

Figure 14-1. Sources of arsenic loadings to Warm Springs Creek.

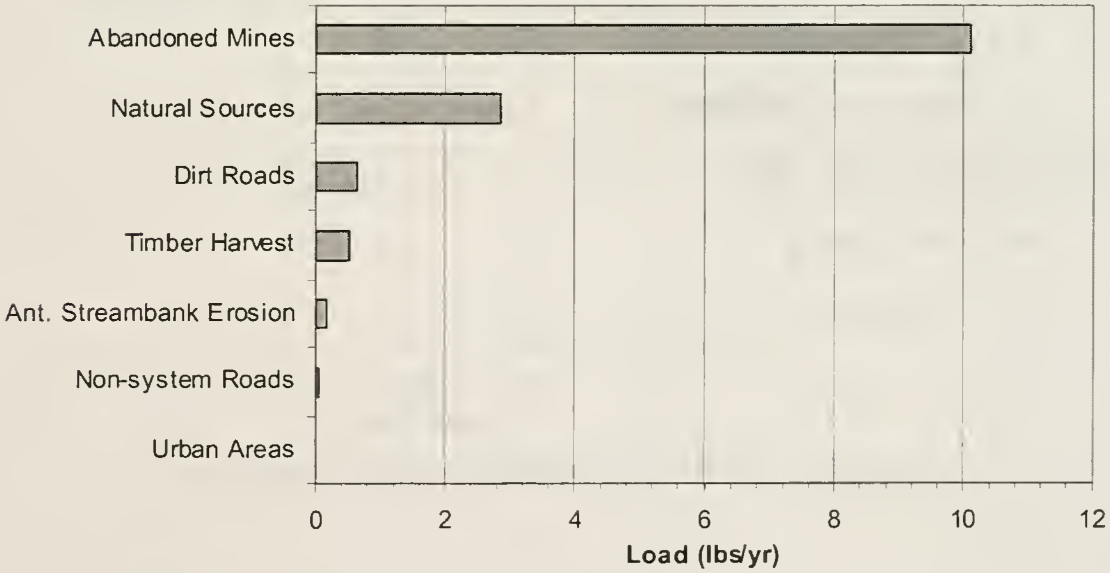

Figure 14-2. Sources of cadmium loadings to Warm Springs Creek.

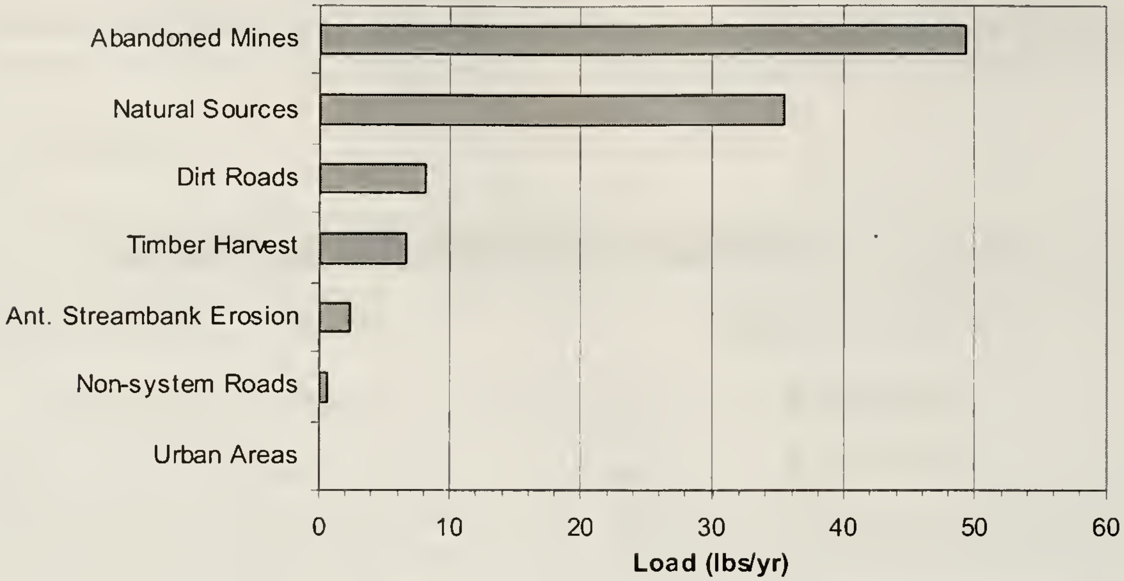

Figure 14-3. Sources of lead loadings to Warm Springs Creek.

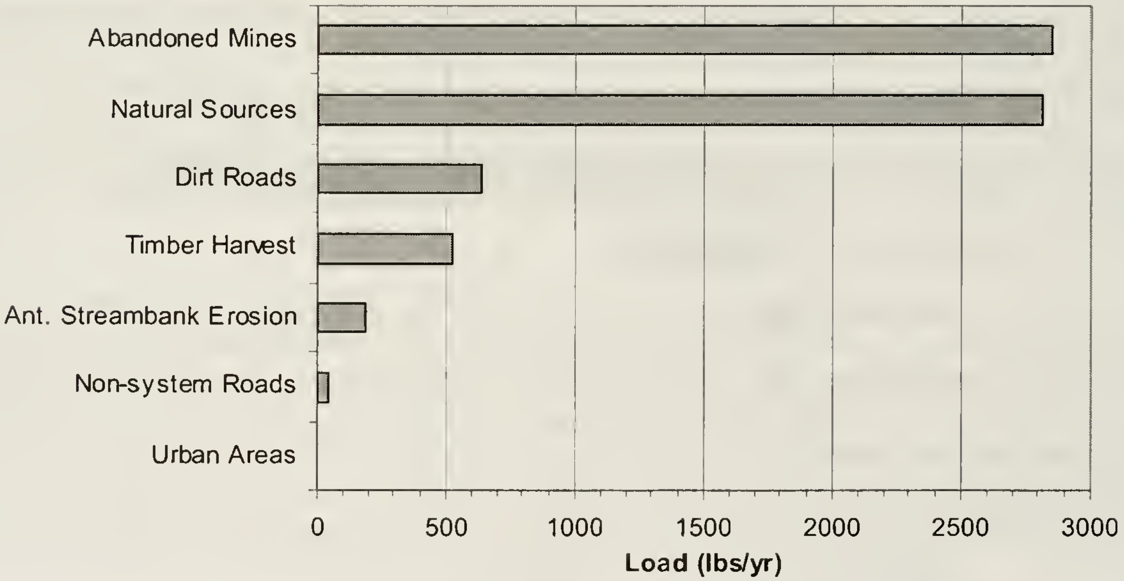

Figure 14-4. Sources of zinc loadings to Warm Springs Creek.

14.1.2 Water Quality Goals/Targets

The ultimate goal of these TMDLs for metals is to attain and maintain the applicable Montana numeric metals standards. Montana water quality metals standards for cadmium, copper, lead, and zinc are dependant on in-stream ambient water hardness concentrations and can therefore vary by stream segment. The target concentrations for metals in the segments of Warm Springs Creek are presented in Table 14-1.

Table 14-1. Montana numeric surface water quality standards for metals in Warm Springs Creek.

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	10[d]
Cadmium (TR)	1.3 at 61.2 mg/L hardness[c]	0.2 at 61.2 mg/L hardness[c]	5
Lead (TR)	43.2 at 61.2 mg/L hardness[c]	1.7 at 61.2 mg/L hardness[c]	15
Zinc (TR)	79.7 at 61.2 mg/L hardness[c]	79.7 at 61.2 mg/L hardness[c]	2,000

14.1.3 Total Maximum Daily Loads, Allocations, and Margin of Safety

The TMDLs, allocations and margin of safety are presented in Tables 14-2 through 14-5. The TMDLs are presented at the scale of the entire Warm Springs Creek watershed and include all tributaries. Based on the results of the source assessment (Section 14.1.1), the recommended implementation strategy to address the metals problem in Warm Springs Creek is to reduce metals loadings from historical mining sites in the watershed, along with the implementation of the sediment TMDLs (see Section 1.2) to reduce sediment attached loading. As shown in Table 14-2 through Table 14-5, the hypothesis is that an overall, watershed scale load reduction of 59, 62, 32, and 44 percent for arsenic, cadmium, lead, and zinc, respectively, will result in achievement of the applicable water quality standards. Warm Springs Creek already meets applicable water quality standards for copper. The proposal for achieving the load reduction is to reduce loads from historical mining by 65, 78, 39, and 71 percent for arsenic, cadmium, lead, and zinc, respectively.

Table 14-2. TMDL, Allocations, and Margin of Safety for Warm Springs Creek – Arsenic.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	396.7	65	138.1	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	3.3	64	1.2	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 64% (see Table 14-6), thereby reducing sediment associated metals loads from streambank erosion by 64%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.9	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	9.5	97	0.3	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	11.6	60	4.6	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 14-6).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban	0.1	80	0.08	An average 80% reduction for sediment-associated metals is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	422.1	66	144.3		
	Natural Sources	50.7	0	50.7	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of arsenic in the Warm Springs Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**472.8**	**59**	**195.0**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 144.3 lbs/yr + 50.7 lbs/yr + 0 = 195.0 lbs/yr** **TMDL = 0 + 0.39 lbs/day + 0.14 lbs/day + 0 = 0.53 lbs/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

Table 14-3. TMDL, Allocations, and Margin of Safety for Warm Springs Creek – Cadmium.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	10.1	77	2.3	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	0.2	64	0.1	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 64% (see Table 14-6), thereby reducing sediment associated metals loads from streambank erosion by 64%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.0	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	0.5	97	0.0	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	0.7	60	0.3	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 14-6).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	11.5	76	2.7		
	Natural Sources	2.8	0	2.8	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of cadmium in the Warm Springs Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**14.3**	**62**	**5.5**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 2.70 lbs/yr + 2.8 lbs/yr + 0 = 5.5 lbs/yr** **TMDL = 0 + 0.007 lbs/day + 0.008 lbs/day + 0 = 0.015 lbs/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

Table 14-4. TMDL, Allocations, and Margin of Safety for Warm Springs Creek – Lead.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	49.4	38	30.4	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	2.3	64	0.8	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 64% (see Table 14-6), thereby reducing sediment associated metals loads from streambank erosion by 64%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	0.6	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	6.6	97	0.2	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	8.1	60	3.2	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 14-6).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban	0.1	80	0.0	An average 80% reduction for sediment-associated metals is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	67.1	48	34.6		
	Natural Sources	35.4	0	35.4	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of lead in the Warm Springs Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		102.5	32	70.0		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 34.6 lbs/yr + 35.4 lbs/yr + 0 = 70.0 lbs/yr** **TMDL = 0 + 0.09 lbs/day + 0.10 lbs/day + 0 = 0.19 lbs/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

Table 14-5. TMDL, Allocations, and Margin of Safety for Warm Springs Creek – Zinc.

Allocation	Source Category	Current Load (lbs/yr)	% Reduction	Allocation (lbs/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	2,849.7	71	814.8	The load reduction for abandoned mines was determined after the sediment (and associated metals) reductions from the sediment TMDLs were applied. After reducing sediment-associated metals from the other sources, loads from the mines were reduced until water quality standards were met.	Loads for abandoned mines were determined during model calibration, and were based on limited in-stream water quality data.
	Anthropogenic Streambank Erosion	184.2	64	66.6	It is assumed that sediment loads from anthropogenic streambank erosion will be reduced by 64% (see Table 14-6), thereby reducing sediment associated metals loads from streambank erosion by 64%.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	49.4	100	0.0	Ideally all non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads or prevent their creation. Therefore, this load reduction may be an overestimate.
	Timber Harvest	526.8	97	15.8	It is assumed that sediment-based metals loading from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Current loads from timber harvest are based on public agency data and coarse assumptions regarding private forest land. Thus the current timber harvest load from private lands may be over or underestimated.
	Unpaved Roads	644.5	60	257.8	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment and corresponding metals load reduction of 60% (See Table 14-6).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Urban	7.4	80	1.5	An average 80% reduction for sediment-associated metals is assumed.	This approach assumes that BMPs will be applied to all areas. This may not be possible or practical given constraints associated with available land area and existing infrastructure. The estimated load reductions may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	4,262.0	73	1,156.5		
	Natural Sources	2,814.0	0	2,814.0	It is assumed that the metals loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of zinc in the Warm Springs Creek Watershed.	
Margin of Safety		NA	0	0	The MOS was applied as a 5% reduction of the target concentration during model TMDL runs.	
Total[1]		**7,076.0**	**44**	**3,970.5**		
TMDL	**TMDL = WLA + LA + Natural + MOS TMDL = 0 + 1,156.5 lbs/yr + 2,814.0 lbs/yr + 0 = 3,970.5 lbs/yr TMDL = 0 + 3.2 lbs/day + 7.7 lbs/day + 0 = 10.9 lbs/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

14.2 SEDIMENT

The available data suggest that Warm Springs Creek is impaired by sediment (See Volume I Report). TMDLs are presented in the following sections to address the sediment impairments. The loading analyses presented in this section are based on application of the GWLF model (Appendix C) as well as the various assessment techniques described in Appendix D. While it is believed that the resulting load estimates are adequate for making relative comparisons, they should not be used directly as quantity estimates.

14.2.1 Sources of Sediment in the Warm Springs Creek Watershed

As shown in Figure 14-5, the primary anthropogenic sources of sediment in the Warm Springs Creek watershed, in descending order of magnitude are unpaved roads, abandoned mines, timber harvest, anthropogenic streambank erosion, and non-system roads.

Unpaved roads account for the greatest percentage (37 percent) of anthropogenic sediment production throughout Warm Springs Creek. Roads cross, and are adjacent to the channel throughout much of the watershed, particularly in the North and Middle Forks. Six abandoned mines (Middle Fork Warm Springs, Solar Silver, Badger, Newburgh/Flemming, White Pine, Warm Springs tailing adit) within Warm Spring Creek were identified as being capable of delivering sediment to a channel within the Warm Springs watershed. With exception of the Badger mine, all of the mines are located within the Middle Fork Warm Springs. The majority of this sediment is related to erosion from tailings piles and disturbed areas. None of these mines have been formally reclaimed, but isolated areas of some of the mines are becoming vegetated. Most of the timber harvest has occurred in the upper watershed. This activity has largely occurred on steep areas of private land. Anthropogenic streambank erosion is largely confined to the main stem of Warm Springs Creek. Causes of this sediment source include riparian grazing, road encroachment, stream channelization, riparian vegetation removal and historic mining activity. Non-system roads/trails were present throughout the uplands of the Warm Springs watershed. The occurrence of these roads/trails in areas of steep topography, and the associated lack of drainage structures typically leads to disproportionately large volumes of sediment generation from this source.

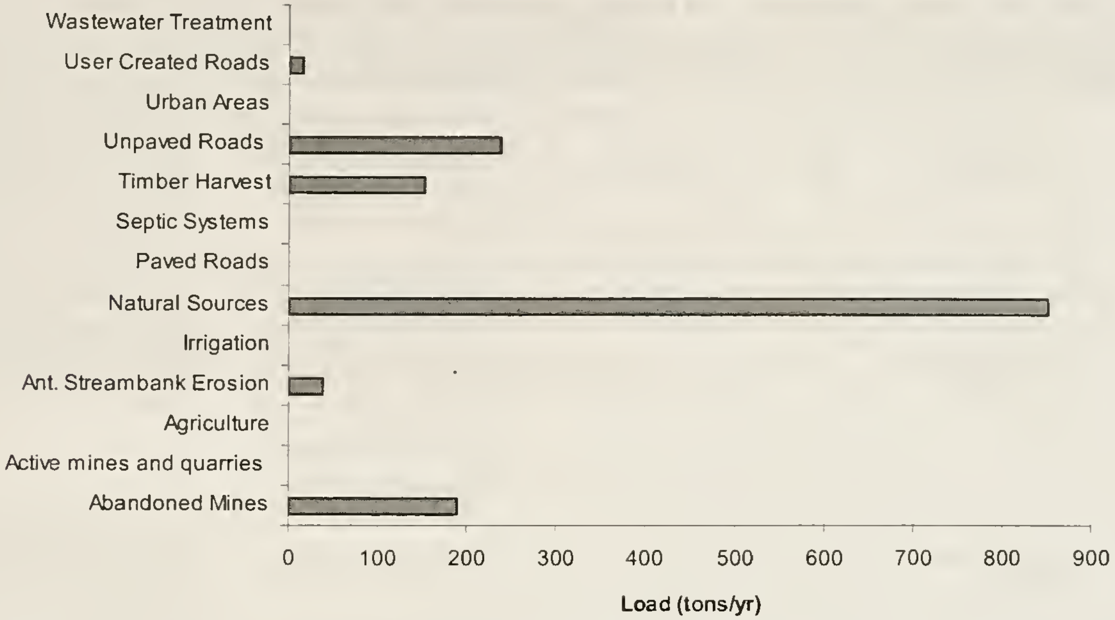

Figure 14-5. Total annual sediment load from all potentially significant sediment sources in the Warm Springs Creek Watershed.

14.2.2 Water Quality Goals/Targets

The ultimate goal of this siltation TMDL is to attain and maintain the applicable Montana narrative sediment standards. The sediment endpoint goals/targets are described in Volume 1, Section 3.1.3.

14.2.3 Total Maximum Daily Load, Allocations, and Margin of Safety

The TMDL, allocations and margin of safety are presented in Table 14-6. The TMDL is presented at the scale of the entire Warm Springs Creek watershed and addresses all of the tributaries. Based on the results of the source assessment (Section 14.2.1), the recommended implementation strategy to address the siltation problem in Warm Springs Creek is to reduce sediment loading from the primary anthropogenic sediment sources – unpaved roads, abandoned mines, timber harvest, anthropogenic streambank erosion, and non-system roads. As shown in Table 14-6, the hypothesis is that an overall, watershed scale sediment load reduction of 32 percent will result in achievement of the applicable water quality standards. The proposal for achieving the load reduction is to reduce loads from current unpaved roads, abandoned mines, timber harvest, anthropogenic streambank erosion, and non-system roads by 60, 79, 97, 64, and 100 percent, respectively.

Table 14-6. TMDL, Allocations, and Margin of Safety for Warm Springs Creek – Siltation.

Allocation	Source Category	Current Load (tons/yr)	% Reduction	Allocation (tons/yr)	Rationale/Assumptions	Uncertainty
Load Allocation	Abandoned Mines	188	67	62	Based on comparison of pre and post-reclamation loads from mines, reclamation results in an average sediment load reduction of 67%.	The range of observed sediment reduction from reclamation at mines in the study area is 0 to 100%. Therefore, load reductions could be over or under estimated.
	Anthropogenic Streambank Erosion	39	64	14	It is estimated that there are 0.9 miles of eroding streambanks (2 x channel length) in the watershed caused by a variety of human activities. It is assumed that streambank erosion will be returned to reference levels based on BEHI values.	It may not be practical or possible to restore all areas of human-caused stream bank erosion to reference levels. Therefore, this load reduction may be an overestimate.
	Non-system Roads	17	100	0	All non-system roads should be closed and reclaimed.	It may not be practical or possible to reclaim all non-system roads. Therefore, this load reduction may be an overestimate.
	Timber Harvest	154	97	5	It is assumed that sediment loading levels from currently harvested areas will return to levels similar to undisturbed full-growth forest through natural recovery.	Even with full BMP implementation, minor quantities of sediment may be delivered in isolated locations. Therefore, this load reduction may be an overestimate.
	Unpaved Roads	237	60	95	It is assumed that no BMPs are currently in place. It is further assumed that all necessary and appropriate BMPs will be employed resulting in an average sediment load reduction of 60% (See Appendix D).	The assumption that no BMPs are currently in place may not be valid. Therefore, the estimated load and load reduction may be an overestimate.
	Total – All Anthropogenic Nonpoint Sources	635	76	176		
	Natural Sources	854	0	854	It is assumed that the sediment loads from all other source categories (i.e., other land uses) are natural in origin and/or negligible.	The loads from these sources are not all entirely natural. There is likely an increment of loading caused by human-activities that could be controlled.
Wasteload Allocation	**All Point Sources**	0	NA	0	There are no point sources of sediment in the Warm Springs Creek Watershed.	
Margin of Safety		NA	0	0	An implicit margin of safety is provided through conservative assumptions associated with most of the estimated load reductions and this TMDL is believed to be the maximum attainable load reduction.	
Total[1]		**1,489**	**31**	**1,030**		
TMDL	**TMDL = WLA + LA + Natural + MOS** **TMDL = 0 + 176 lbs/yr + 854 lbs/yr + 0 = 1,030 lbs/yr** **TMDL = 0 + 0.5 lbs/day + 2.3 lbs/day + 0 = 2.8 lbs/day**					

[1] The total maximum daily load can be expressed as the percent reduction or the total allocation presented in this row.

15.0 SUMMARY OF TMDLS

In all, 131 303(d) listed waterbody-pollutant combinations were evaluated for the Lake Helena TMDL Planning Area. Of these, 118 have been addressed: 63 through the completion of TMDLs, 41 by other subwatershed-scale TMDLs (e.g., upper reaches of Prickly Pear Creek addressed by a single Prickly Pear Creek Watershed TMDL), and 14 by providing documentation that water quality standards are currently met and no TMDL is necessary. The remaining 13 have not been addressed due to lack of sufficient data to determine the current impairment status or insufficient data to complete the necessary TMDLs. Table 15-1 provides a review of all of the 303(d) listed waterbodies described above, including their impairment status, targets/goals, TMDLs, and supporting documentation.

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Clancy Creek, MT41I006_120	Siltation/ Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	2,486 tons/yr	WLA: 0 LA: 2,486	Volume I; Volume II – Appendix A, C, and D
	Nutrients	No nutrient TMDL needed, not exceeding the narrative nutrient standards.			Volume I
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	279.4 lbs/yr	WLA: 0 LA: 279.4 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 2.3 µg/L at 105.6 mg/L hardness • Aquatic Life (chronic): 0.3 µg/L at 105.6 mg/L hardness • Human Health: 5 µg/L	13.2 lbs/yr	WLA: 0 LA: 13.2 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 14.6 µg/L at 105.6 mg/L hardness • Aquatic Life (chronic): 9.6 µg/L at 105.6 mg/L hardness • Human Health: 1,300 µg/L	517.6 lbs/yr	WLA: 0 LA: 517.6 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 86.3 µg/L at 105.6 mg/L hardness • Aquatic Life (chronic): 3.3 µg/L at 105.6 mg/L hardness • Human Health: 15 µg/L	155.8 lbs/yr	WLA: 0 LA: 155.8 lbs/yr	Volume I; Volume II – Appendix A and F
	Mercury	Insufficient data, not addressed in Volume II.			
	Zinc	• Aquatic Life (acute): 126.5 µg/L at 105.6 mg/L hardness • Aquatic Life (chronic): 126.5 µg/L at 105.6 mg/L hardness • Human Health: 2,000 µg/L	10613.3 lbs/yr	WLA: 0 LA: 10613.3 lbs/yr	Volume I; Volume II – Appendix A and F
Corbin Creek, MT41I006_090	pH	No TMDL needed, not exceeding the standards.			Volume I
	Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	368 tons/yr	WLA: 0 LA: 368 tons/yr	Volume I; Volume II – Appendix A, C, and D

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	36.2 lbs/yr	WLA: 0 LA: 36.2 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 8.95 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 0.75 µg/L at 400 mg/L hardness • Human Health: 5 µg/L	2.8 lbs/yr	WLA: 0 LA: 2.8 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 51.0 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 29.8 µg/L at 400 mg/L hardness • Human Health: 1,300 µg/L	114.6 lbs/yr	WLA: 0 LA: 114.6 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 468.3 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 18.2 µg/L at 400 mg/L hardness • Human Health: 15 µg/L	33.2 lbs/yr	WLA: 0 LA: 33.2 lbs/yr	Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 392.6 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 392.6 µg/L at 400 mg/L hardness • Human Health: 2,000 µg/L	1,660.7 lbs/yr	WLA: 0 LA: 1,660.7 lbs/yr	Volume I; Volume II – Appendix A and F
	Thermal Modifications	• ≤ 1° F change when water temperature is < 67 ° F • No significant disturbance of riparian vegetation; Riparian vegetation approaching the maximum potential. • MFISH rating of "best" or "substantial" • Maintain recommended MFWP flows	Volume I stated that, "The available data suggest that impairments due to metals and siltation currently far outweigh any concerns posed by thermal modifications. Fisheries data suggest that the stream is not inhabited by fish. It is not recommended that a TMDL for temperature be prepared at this time. Once pollutant levels are reduced in the stream, Corbin Creek should be able to sustain a fish population and the application of the B-1 temperature targets would be appropriate."		
	Salinity/ TDS/Cl	Addressed as part of the metals goals and TMDLs. Volume I found that, "The impairment is likely associated with extremely high trace metals concentrations rather than high concentrations of sulfates, sodium, or chlorides. The project team finds that a specific TMDL to address salinity and total dissolved solids issues is not warranted pending implementation of a metals TMDL."			
Golconda Creek, MT41I006_070	Unknown Toxicity	The 1996 list did not have more specific details about the "unknown toxicity." Investigations performed during the Volume I report revealed that the unknown toxicity was most likely due to metals. The impairment is addressed as part of the cadmium and lead TMDLs.			Volume I
	Suspended Solids/ Turbidity	No suspended solids or turbidity TMDLs needed, not exceeding the narrative standards.			Volume I
	Cadmium	• Aquatic Life (acute): 0.8 µg/L at 38.5 mg/L hardness • Aquatic Life (chronic): 0.1 µg/L at 38.5 mg/L hardness • Human Health: 5 µg/L	0.7 lb/yr	WLA: 0 LA: 0.7lb/yr	Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Lead	• Aquatic Life (acute): 23.9 µg/L at 38.5 mg/L hardness • Aquatic Life (chronic): 0.9 µg/L at 38.5 mg/L hardness • Human Health: 15 µg/L	6.3 lbs/yr	WLA: 0 LA: 6.3 lbs/yr	Volume I; Volume II – Appendix A and F
Granite Creek MT41I006_179 (Tributary to Austin Creek)	No pollutants	No TMDLs necessary.			Volume I
Granite Creek, MT41I006_230 (Tributary to Sevenmile Creek)	Arsenic	No flow was observed in Granite Creek. Therefore, insufficient information is available to determine impairment status.			Volume I
	Cadmium	No flow was observed in Granite Creek. Therefore, insufficient information is available to determine impairment status.			Volume I
	Lead	No flow was observed in Granite Creek. Therefore, insufficient information is available to determine impairment status.			Volume I
Jackson Creek, MT41I006_190	Siltation	No siltation TMDL needed, not exceeding the narrative standards.			Volume I
Jennie's Fork, MT41I006_210	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	306 lbs/yr	WLA: 0 LA: 306 lbs/yr	Volume I; Volume II – Appendix A, C, and D
	Lead	• Aquatic Life (acute): 118.7 µg/L at 135.8 mg/L hardness • Aquatic Life (chronic): 4.6 µg/L at 135.8 mg/L hardness • Human Health: 15 µg/L	8.4 lbs/yr	WLA: 0 LA: 8.4 lbs/yr	Volume I; Volume II – Appendix A and F
Lake Helena, MT41I007_010	Suspended Solids	Impairment status unknown. Volume I states, "insufficient information is available to evaluate the degree of potential sediment impairment in Lake Helena, if any. A suitable reference lake would be needed to evaluate the sediment impairment of Lake Helena."			Volume I
	Nutrients	Insufficient data are currently available to establish nutrient targets for Lake Helena. A strategy to establish targets in the future is presented in Volume II, Section 3.2.3. TMDLs are presented based on % reductions for Prickly Pear Creek (the largest tributary to Lake Helena).	TN: 226.2 tons/yr TP: 20.7 tons/yr	**TN** WLA: 4.4 tons/yr LA: 221.8 tons/yr **TP** WLA: 1.8 lbs/yr LA: 18.9 lbs/yr	Volume I Appendix A, C, D, E, I, and K Volume II, Section 3.2.3 (Nutrient Strategy)
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	5,104.2 lbs/yr	WLA: 149.2 lbs/yr LA: 4,955.0 lbs/yr	Volume I; Volume II – Appendices A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Lead	• Aquatic Life (acute): 157.6 µg/L at 169.7 mg/L hardness • Aquatic Life (chronic): 6.1 µg/L at 169.7 mg/L hardness • Human Health: 15 µg/L	2,798.0 lbs/yr	WLA: 66.8 lbs/yr LA: 2,731.2	Volume I; Volume II – Appendices A and F
	Thermal Modifications	Unknown impairment status.			Volume I
Lump Gulch, MT41I006_130	Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	1,780 tons/yr	WLA: 0 LA: 1,780 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Cadmium	• Aquatic Life (acute): 1.1 µg/L at 51.4 mg/L hardness • Aquatic Life (chronic): 0.2 µg/L at 51.4 mg/L hardness • Human Health: 5 µg/L	10.4 lbs/yr	WLA: 0 LA: 10.4 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 7.4 µg/L at 51.4 mg/L hardness • Aquatic Life (chronic): 5.2 µg/L at 51.4 mg/L hardness • Human Health: 1,300 µg/L	452.8 lbs/yr	WLA: 0 LA: 452.8 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 34.6 µg/L at 51.4 mg/L hardness • Aquatic Life (chronic): 1.3 µg/L at 51.4 mg/L hardness • Human Health: 15 µg/L	135.3 lbs/yr	WLA: 0 LA: 135.3 lbs/yr	Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 68.6 µg/L at 51.4 mg/L hardness • Aquatic Life (chronic): 68.6 µg/L at 501.4mg/L hardness • Human Health: 2,000 µg/L	8,485.9 lbs/yr	WLA: 0 LA: 8,485.9 lbs/yr	Volume I; Volume II – Appendix A and F
	Mercury	Insufficient data, not addressed in Volume II.			

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Middle Fork Warm Springs Creek, MT41I006_100	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A, C, and D
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 1.3 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 0.2 µg/L at 61.2 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
	Copper	No copper TMDL needed, not exceeding the standards.			
	Lead	• Aquatic Life (acute): 43.2 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 1.7 µg/L at 61.2 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 79.7 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 79.7 µg/L at 61.2 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
	Mercury	Insufficient data, not addressed in Volume II.			
North Fork Warm Springs Creek, MT41I006_180	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A, C, and D
	Low DO, organic enrichment	No nutrient TMDL needed, not exceeding the narrative standards.			Volume I
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Cadmium	• Aquatic Life (acute): 1.3 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 0.2 µg/L at 61.2 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 79.7 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 79.7 µg/L at 61.2 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Warm Springs Creek watershed TMDL.		Volume I; Volume II – Appendix A and F
Prickly Pear Creek, MT41I006_060	Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A, C, and D
	Lead	• Aquatic Life (acute): 238.5 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 9.2 µg/L at 235.1 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
Prickly Pear Creek, MT41I006_050	Siltation/ Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A, C, and D
	Cadmium	• Aquatic Life (acute): 5.2 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 0.5 µg/L at 235.1 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 238.5 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 9.2 µg/L at 235.1 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Zinc	• Aquatic Life (acute): 249.9 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 249.9 µg/L at 235.1 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
Prickly Pear Creek, MT41I006_040	Siltation/ Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II -- Appendix A, C, and D
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 5.2 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 0.5 µg/L at 235.1 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 31.0 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 18.9 µg/L at 235.1 mg/L hardness • Human Health: 1,300 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 238.5 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 9.2 µg/L at 235.1 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 249.9 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 249.9 µg/L at 235.1 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Thermal Modifications	• ≤ 1°F when water temperature is < 67°F • 60 Percent Riparian Shade • MFISH rating of "best" or "substantial" • Maintain minimum MFWP recommended flows	67 °F	WLA: LA: 67 °F	Volume I; Volume II – Appendix A, Appendix G, Appendix E

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Prickly Pear Creek, MT41I006_030	Siltation/ Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A, C, and D
	Nutrients	TN: 0.33 mg/L TP: 0.04 mg/L (A strategy to revise these targets is presented in Volume II and Appendix I)	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Appendix A, C, D, E, I, and K Volume II, Section 3.2.3 (Nutrient Strategy)
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 5.2 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 0.5 µg/L at 235.1 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 31.0 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 18.9 µg/L at 235.1 mg/L hardness • Human Health: 1,300 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 238.5 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 9.2 µg/L at 235.1 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 249.9 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 249.9 µg/L at 235.1 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Prickly Pear Creek watershed TMDL (Segment MT41I006_020).		Volume I; Volume II – Appendix A and F
	Thermal Modifications	• ≤ 1°F when water temperature is < 67°F • 60 Percent Riparian Shade • MFISH rating of "best" or "substantial" • Maintain minimum MFWP recommended flows	No TMDL is presented at this time. This segment is completely dewatered during critical summer low flow conditions. Reassessment should occur once the stream meets recommended minimum summer flows.		Volume I; Volume II – Appendix A, Appendix G, Appendix E

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Prickly Pear Creek, MT41I006_020	Siltation/ Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	24,186 tons/yr	WLA: 54 tons/yr LA: 24,132 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Nutrients	TN: 0.33 mg/L TP: 0.04 mg/L (A strategy to revise these targets is presented in Volume II and Appendix I)	TN: 111.7 tons/yr TP: 13.6 tons/yr	**TN** WLA: 3.7 tons/yr LA: 108.0 tons/yr **TP** WLA: 1.6 ton/yr LA: 12.0 tons/yr	Volume I; Appendix A, C, D, E, and I; Volume II, Section 3.2.3 (Nutrient Strategy)
	Ammonia	No ammonia TMDL needed, not exceeding the standards.			Volume I
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	3,943 lbs/yr	WLA: 149 lbs/yr LA: 3,794 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 5.2 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 0.5 µg/L at 235.1 mg/L hardness • Human Health: 5 µg/L	171 lbs/yr	WLA: 12 lbs/yr LA: 159 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 31.0 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 18.9 µg/L at 235.1 mg/L hardness • Human Health: 1,300 µg/L	5,969 lbs/yr	WLA: 149 lbs/yr LA: 5,820 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 238.5 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 9.2 µg/L at 235.1 mg/L hardness • Human Health: 15 µg/L	2,082 lbs/yr	WLA: 67 lbs/yr LA: 2,015 lbs/yr	Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 249.9 µg/L at 235.1 mg/L hardness • Aquatic Life (chronic): 249.9 µg/L at 235.1 mg/L hardness • Human Health: 2,000 µg/L	118,617 lbs/yr	WLA: 1,977 lbs/yr LA: 116,640 lbs/yr	Volume I; Volume II – Appendix A and F
	Thermal Modifications	• ≤ 1°F when water temperature is < 67°F • 60 Percent Riparian Shade • MFISH rating of "best" or "substantial" • Maintain minimum MFWP recommended flows	No TMDL is presented at this time. This previous segment is completely dewatered during critical summer low flow conditions. Reassessment should occur once the stream meets recommended minimum summer flows.		Volume I; Volume II – Appendix A, Appendix G, Appendix E

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Prickly Pear Creek, MT41I006_010	Metals	This segment of Prickly Pear Creek is located downstream of Lake Helena, and is therefore outside the scope of this assessment. Segment MT41I006_010 will be assessed at a future date as part of the Hauser Lake/Missouri River Planning Area.			
Sevenmile Creek, MT41I006_160	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	3100 tons/yr	WLA: 0 LA: 3100	Volume I; Volume II – Appendix A, C, and D
	Nutrients	TN: 0.33 mg/L TP: 0.04 mg/L (A strategy to revise these targets is presented in Volume II and Appendix I)	TN: 12.26 tons/yr TP: 1.59 tons/yr	**TN** WLA: 0 tons/yr LA: 12.26 tons/yr **TP** WLA: 0 ton/yr LA: 1.59 tons/yr	Volume I; Appendix A, C, D, E, I, and K Volume II, Section 3.2.3 (Nutrient Strategy)
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	578.7 lbs/yr	WLA: 0 LA: 578.7 lbs/yr	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 33.6 µg/L at 256.4 mg/L hardness • Aquatic Life (chronic): 20.4 µg/L at 256.4 mg/L hardness • Human Health: 1,300 µg/L	828.0 lbs/yr	WLA: 0 LA: 828.0 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 266.2 µg/L at 256.4 mg/L hardness • Aquatic Life (chronic): 10.3 µg/L at 256.4 mg/L hardness • Human Health: 15 µg/L	283.7 lbs/yr	WLA: 0 LA: 283.7 lbs/yr	Volume I; Volume II – Appendix A and F
Silver Creek, MT41I006_150	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	968.3 lbs/yr	WLA: 0 LA: 968.3 lbs/yr	Volume I; Volume II – Appendix A and F
	Priority organics	No TMDL needed, not exceeding standards.			Volume I

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
Skelly Gulch, MT41I006_220	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	1,097 tons/yr	WLA: 0 LA: 1,097 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Metals	No TMDL needed, not exceeding standards.			Volume I
Spring Creek, MT41I006_080	Suspended Solids	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	1,954 tons/yr	WLA: 0 LA: 1,954 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Nutrients	TN: 0.33 mg/L TP: 0.04 mg/L (A strategy to revise these targets is presented in Volume II and Appendix I)	TN: 5.84 tons/yr TP: 0.95 tons/yr	**TN** WLA: 0 LA: 5.84 tons/yr **TP** WLA: 0 LA: 0.95 tons/yr	Volume I; Appendix A, C, D, E, I, and K Volume II, Section 3.2.3 (Nutrient Strategy)
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	294.6 lbs/yr	WLA: 81.2 lbs/yr LA: 213.4 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 8.95 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 0.75 µg/L at 400 mg/L hardness • Human Health: 5 µg/L	15.9 lbs/yr	WLA: 4.1 lbs/yr LA: 11.8	Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 51.0 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 29.8 µg/L at 400 mg/L hardness • Human Health: 1,300 µg/L	668.0 lbs/yr	WLA: 77.6 lbs/yr LA: 590.4 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 468.3 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 18.2 µg/L at 400 mg/L hardness • Human Health: 15 µg/L	219.8 lbs/yr	WLA: 51.1 lbs/yr LA: 168.7 lbs/yr	Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Zinc	• Aquatic Life (acute): 392.6 µg/L at 400 mg/L hardness • Aquatic Life (chronic): 392.6 µg/L at 400 mg/L hardness • Human Health: 2,000 µg/L	14,399 lbs/yr	WLA: 1,770 lbs/yr LA: 12629 lbs/yr	Volume I; Volume II – Appendix A and F
	pH	No TMDL needed, not exceeding standards.			Volume I
Tenmile Creek, MT41I006_141	Siltation	No TMDL needed, not exceeding standards.			Volume I
	pH	No TMDL needed, not exceeding standards.			Volume I
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 2.3 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 0.3 µg/L at 106.5 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 14.7 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 9.7 µg/L at 106.5 mg/L hardness • Human Health: 1,300 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 87.2 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 3.4 µg/L at 106.5 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Mercury	Insufficient data, not addressed in Volume II.			
	Zinc	• Aquatic Life (acute): 127.5 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 127.5 µg/L at 106.5 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
Tenmile Creek, MT41I006_142	pH	No TMDL needed, not exceeding standards.			Volume I
	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A, C, and D
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Cadmium	• Aquatic Life (acute): 2.3 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 0.3 µg/L at 106.5 mg/L hardness • Human Health: 5 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Copper	• Aquatic Life (acute): 14.7 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 9.7 µg/L at 106.5 mg/L hardness • Human Health: 1,300 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 87.2 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 3.4 µg/L at 106.5 mg/L hardness • Human Health: 15 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 127.5 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 127.5 µg/L at 106.5 mg/L hardness • Human Health: 2,000 µg/L	Load allocations are presented as part of the Tenmile Creek watershed TMDL (Segment MT41I006_143).		Volume I; Volume II – Appendix A and F
Tenmile Creek, MT41I006_143	Mercury	Insufficient data, not addressed in Volume II.			
	pH	No TMDL needed, not exceeding standards.			Volume I
	Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	8,247 tons/yr	WLA: 0 LA: 8,247 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Nutrients	TN: 0.33 mg/L TP: 0.04 mg/L (A strategy to revise these targets is presented in Volume II and Appendix I)	TN: 44.47 tons/yr TP: 4.39 tons/yr	**TN** WLA: 0 tons/yr LA: 44.47 tons/yr **TP** WLA: 0 ton/yr LA: 4.39 tons/yr	Volume I; Appendix A, C, D, E, I, and K Volume II, Section 3.2.3 (Nutrient Strategy)
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	1,912.6 lbs/yr	WLA: 0 LA: 1,912.6 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 2.3 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 0.3 µg/L at 106.5 mg/L hardness • Human Health: 5 µg/L	67.6 lbs/yr	WLA: 0 LA: 67.6 lbs/yr	Volume I; Volume II – Appendix A and F

Table 15-1. Summary of 303(d) listed streams, pollutants, and TMDLs in the Lake Helena watershed.

Waterbody Name	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	WLA LA	Supporting Documentation
	Copper	• Aquatic Life (acute): 14.7 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 9.7 µg/L at 106.5 mg/L hardness • Human Health: 1,300 µg/L	2,232.4 lbs/yr	WLA: 0 LA: 2,232.4 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 87.2 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 3.4 µg/L at 106.5 mg/L hardness • Human Health: 15 µg/L	734.1 lbs/yr	WLA: 0 LA: 734.1 lbs/yr	Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 127.5 µg/L at 106.5 mg/L hardness • Aquatic Life (chronic): 127.5 µg/L at 106.5 mg/L hardness • Human Health: 2,000 µg/L	43,706.0 lbs/yr	WLA: 0 LA: 43,706.0 lbs/yr	Volume I; Volume II – Appendix A and F
Warm Springs Creek, MT41I006_110	Suspended Solids, Siltation	• % of subsurface fines < 6.4 mm: < or = to the average value for all Helena National Forest reference stream core samples • % of surface fines < 2.0 mm: 0.2 • Width/depth ratio: Comparable to reference values. • BEHI: Comparable to reference values. • D50: Comparable to reference values. • PFC: Proper Functioning Condition or "Functional - at Risk" with an upward trend. • Macro IBI: To be determined	1,030 tons/yr	WLA: 0 LA: 1,030 tons/yr	Volume I; Volume II – Appendix A, C, and D
	Arsenic	• Aquatic Life (acute): 340 µg/L • Aquatic Life (chronic): 150 µg/L • Human Health: 10 µg/L	195.0 lbs/yr	WLA: 0 LA: 195.0 lbs/yr	Volume I; Volume II – Appendix A and F
	Cadmium	• Aquatic Life (acute): 1.3 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 0.2 µg/L at 61.2 mg/L hardness • Human Health: 5 µg/L	5.5 lbs/yr	WLA: 0 LA: 5.5 lbs/yr	Volume I; Volume II – Appendix A and F
	Lead	• Aquatic Life (acute): 43.2 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 1.7 µg/L at 61.2 mg/L hardness • Human Health: 15 µg/L	70.0 lbs/yr	WLA: 0 LA: 70.0 lbs/yr	Volume I; Volume II – Appendix A and F
	Zinc	• Aquatic Life (acute): 79.7 µg/L at 61.2 mg/L hardness • Aquatic Life (chronic): 79.7 µg/L at 61.2 mg/L hardness • Human Health: 2,000 µg/L	3,970.5 lbs/yr	WLA: 0 LA: 3,970.5 lbs/yr	Volume I; Volume II – Appendix A and F

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Appendix B

DEQ and EPA Response to Public Comments Received on the Volume I and Volume II Lake Helena TMDL Documents

Framework Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area:

Volume II – Final Report

August 31, 2006

Prepared for the Montana Department of Environmental Quality

Prepared by the U.S. Environmental Protection Agency,
Montana Operations Office
With Technical Support from Tetra Tech, Inc.
and PBS&J, Inc.

Project Manager: Ron Steg

Volume I Response to Comments

The formal public comment period on the Lake Helena Volume I document extended from February 28, 2004 to March 30, 2005. Two individuals submitted formal written comments. In addition, several people voiced concerns and/or raised questions at the March 15, 2005 public informational meeting in Helena on the Volume I report. These formal and verbal comments and questions have been summarized below. Responses prepared by EPA and DEQ follow each of the individual comments. The original comment letters are located in the project files at DEQ and may be reviewed upon request.

1. **Comment:** I own private property with frontage along Sevenmile Creek. My property includes obvious sediment sources to the stream and I'm interested in working cooperatively to address these problems. Who should I contact?

   Response: DEQ and EPA staff will be happy to meet with you on site to discuss management alternatives and sources of assistance. You can also contact the local office of the Natural Resources Conservation Service and the Lower Tenmile Watershed Group.

2. **Comment:** How much consideration is given within the TMDL development process to natural gaining or losing reaches of streams, particularly with regard to how these factors may affect pollutant concentrations, loads and allocations?

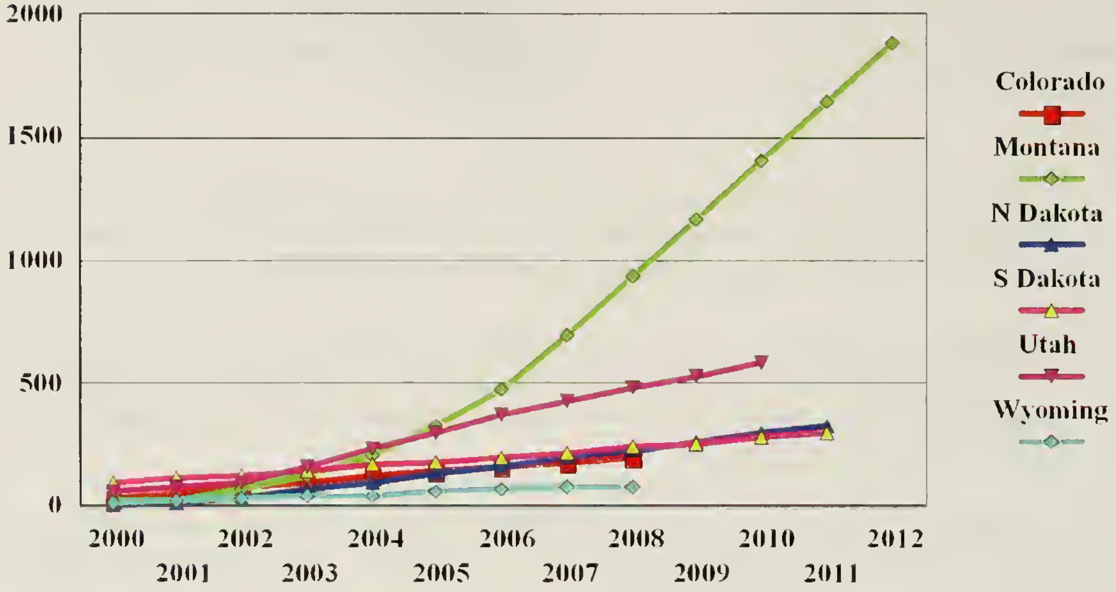
   Response: Spatial variations in streamflow, whether natural or man caused, are always considered when TMDLs are established because of their influence on pollutant concentrations and loads. TMDLs must provide a means of attaining and maintaining water quality standards throughout the stream segment of concern despite variations inflows which may be present.

3. **Comment:** What has been done to date to engage Jefferson County officials in the Lake Helena watershed restoration planning process?

   Response: Jefferson County representatives are included on the Lake Helena project technical and policy advisory committees, including the country commissioners, planning director, planning and zoning office, environmental health office, the disaster and emergency services coordinator, the Jefferson County weed district, and the Jefferson Valley Conservation District. In addition, Lake Helena project staff has frequently attended Jefferson Valley Conservation District meetings to provide updates on the project and answer questions.

4. **Comment:** How does Montana's 303(d) List compare to those compiled for adjacent states?

   Response: In general, Montana has as many or more listed streams than adjacent states due to its headwaters location, abundant surface water resources, protective water quality standards, and rigorous assessment process. A comparison of all the EPA Region VIII states showing the total number of 303(d) listed waters and approximate number of TMDLs to be completed on an annual basis (i.e., cumulative) is shown below:



5. **Comment:** How are water use support determinations made? Do the same standards and expectations apply to all streams? How are the various data interpreted relative to water quality standards attainment?

   Response: Montana's water use support decisions are based on the relevant state water quality standards, directives contained in 1997 amendments to the Montana Water Quality Act, and internal agency guidance known as the "Sufficient Credible Data/Beneficial Use Support" procedures. This process is described in detail on the Montana DEQ website at: http://www.deq.state.mt.us/wqinfo/datamgmt/PDF/SufficientCredibleData.pdf

6. **Comment:** Please provide an explanation of and background on the TMDL lawsuit that was filed in 1997.

   Response: EPA was sued by the Friends of the Wild Swan, American Wildlands, the Montana Environmental Information Center, the Ecology Center and the Alliance for the Wild Rockies in 1997 and in 2002 over the efforts of Montana to develop a list of waters not meeting water quality standards and establishment of TMDLs for those impaired water bodies. This resulted in a court imposed schedule requiring the completion of all necessary TMDLs (based on the 1996 303(d) list) by May 5, 2007.

EPA and DEQ successfully convinced the groups that more time was needed to take a watershed-based approach to development of TMDLs. A joint Motion to Amend Judgment was filed in U.S. District Court in Missoula on November 18, 2004 settling these two lawsuits related to the State of Montana's Total Maximum Daily Load (TMDL) program. The Montana TMDL schedule has been extended until December 2012.

7. **Comment:** How can the TMDL water quality restoration process possibly be successful when most problems result from non-point source pollution and considering that the Montana approach to dealing with non-point sources is voluntary cooperation?

Response: You are correct that the majority of the water quality problems represented on the 303(d) list stem from non-point source pollution. On a stream or lake specific basis, the problems frequently result from the cumulative effects of many individual diffuse sources emanating over large geographical areas. The individual contributing sources may be relatively unimportant, but collectively they create problems. It is difficult to solve these kinds of problems using regulatory approaches because cause and effect relationships may be unclear and supporting data are oftentimes limited. Montana has learned from past experience that cooperative approaches, coupled with on-the-ground monitoring and adaptive management, is the only practical way to deal with non-point source pollution on a statewide basis. Local watershed groups and conservation districts that build coalitions and engage landowners in the restoration process have key roles in this process.

8. **Comment:** Can we anticipate that non-point source pollution controls will become mandatory (and thereby enforceable) rather than voluntary at some point in the future?

Response: In our opinion, we don't anticipate that this will happen in the foreseeable future. The voluntary approach seems to be working well in Montana and the voluntary cooperative components of TMDLs are being implemented with a high degree of success. Successful implementation virtually assures that mandatory approaches won't be required. An exception might be voluntary non-point source controls on federal lands. Recent lawsuits have resulted in court orders blocking development activities pending completion of TMDLs and associated monitoring plans that can demonstrate compliance.

9. **Comment:** I am fearful that the Lake Helena plan cannot be effective at restoring water quality if it's primarily a voluntary, cooperative plan.

Response: See response to comment number 7 above.

10. **Comment:** Based on your experiences in other states, how frequently do watershed TMDLs lead to local ordinances or other local regulations to control various source categories?

    Response: There are a wide variety of local measures that have been adopted in other states to address water quality impairment issues, either as a part of TMDLs or other initiatives. Many of these address urban growth related sources. In Montana's Clark Fork watershed, local ordinances have been adopted to ban the sale of high phosphate content detergents which were found to be a significant source of nutrient loading contributing to nuisance algae growth. Local building set-back requirements have also been adopted to protect lakes such as Flathead Lake. In most of these cases, the TMDLs were not the primary incentive, per se, for adopting the controls.

11. **Comment:** Why are Montana DEQ TMDL staff people not present at tonight's meeting if they are charged with implementing the TMDL program? .

    Response: Montana DEQ and EPA have joint responsibilities and a cooperative plan for implementing the TMDL provisions of the Montana Water Quality Act and the federal Clean Water Act. Each agency is a taking a lead role in completing a share of the required TMDLs, while both agencies must approve the final plans. EPA has assumed a lead role in the Lake Helena TMDL development effort.

12. **Comment:** The Lewis and Clark Water Quality Protection District (WQPD) is a major stakeholder representing Lewis and Clark County residents and two watershed groups. We are interested in having an opportunity to participate more actively in the planning process. As this document has been finalized and no changes are being made based on the comments provided, the opportunity for meaningful input is minimized.

    Response: The steps taken by EPA and DEQ to involve watershed stakeholders in the Lake Helena TMDL process are summarized in Section 5.0 of Volume II. Also, comments received on Volume I and throughout the process have resulted in a number of changes that are now reflected in the Volume II document. Comments have resulted in an expanded source assessment effort and reconsideration of the draft water quality targets. For example, largely in response to stakeholder comments on Volume I, the nutrient targets presented in Section 3.2 of Volume II are considered interim targets and include a strategy to revise them in the future if necessary.

13. **Comment:** The Volume I report represents a tremendous research effort and clearly reflects the complexity of the Lake Helena Watershed. One area that is not adequately covered by the report is the interaction of surface water and ground water, particularly in the lower basin and Helena Valley. It has been shown that the principal surface and groundwater discharge point is Lake Helena.

At the same time, the county health department has identified approximately 5500 homes in the Helena Valley that dispose of their household wastewater to subsurface treatment systems or community systems that discharge to groundwater. This source category may be an important contributor to surface water quality impairments and given a countywide growth rate of 17% over the last decade, we can only expect increases in pollutants from septic systems and non-point sources related to urban and suburban development. As work progresses on the restoration plan and development of TMDLs for the area, we respectfully request a more in-depth look at surface-groundwater interactions in the Helena Valley.

Response: We acknowledge the paucity of data and information pertaining to groundwater-surface water interactions in the Helena Valley and share your concerns and recommend collecting additional data to address this issue(see Appendix H).

The modeling tools that have been developed to date to support the analysis of nutrients do, in fact, allow for consideration of loading from septic systems and urban/suburban development. A plan to enhance these modeling tools in the future is proposed in Appendix H. Further, it is acknowledged that nutrient loading from septic systems and urban/suburban development is likely going to increase in the future. A plan to address these future sources is presented in Volume II, Section 4.5.4

14. **Comment:** An ecoregion-based and modeling approach drawing from reference conditions in other water bodies was used to establish in-lake nutrient concentration targets for Lake Helena. This may not be appropriate since Lake Helena is man-made and shallow. Water quality targets based on so called "natural" lake conditions may not be attainable for Lake Helena and it may not be possible to develop a practical TMDL to meet unattainable water quality targets. Additionally, the report acknowledges that Lake Helena does not continuously discharge water to Hauser Reservoir but may, on occasion, receive inflow from Hauser Reservoir depending on the respective water levels of the two reservoirs. This interaction most certainly affects water quality in Lake Helena, but is not discussed in Volume I. Setting targets without consideration of this fact seems premature.

Response: We agree with your concern about the appropriateness of the Lake Helena nutrient targets proposed in Volume I. As a result, no in-lake nutrient targets are proposed and a strategy to establish targets in the future is presented in Volume II, Section 3.2.3. However, Volume II does acknowledge that water quality in Lake Helena is degrading and actions are necessary to reduce nutrient loading. Since no concentration targets have been proposed for Lake Helena at this time, on an interim basis, it is assumed that the load reductions for Prickly Pear Creek (the largest tributary to Lake Helena) adequately approximate the necessary load reductions for Lake Helena.

15. **Comment:** The water quality targets for nutrients, sediment and water temperature selected for Prickly Pear Creek above Tenmile Creek may be inappropriate and unattainable due to intensive land uses, historical disturbances, and chronic stream dewatering.

    Response: We agree relative to nutrients and have, therefore, presented the nutrient targets in Volume II as "interim" targets in association with an adaptive management strategy to revise them in the future, as appropriate. Flexibility is also provided in Volume II to revise the temperature and sediment targets in the future if necessary.

16. **Comment:** The Volume I report indicates that Sevenmile Creek is impaired for metals and in need of TMDLs for copper and lead. However, in the narrative section for this stream on page 158 under metal concentrations it is stated, "This evidence suggests this segment does not meet the human health criterion for arsenic." Therefore we believe that a TMDL for arsenic is necessary for Sevenmile Creek.

    Response: This was an error in the draft Volume I report. Copper, lead and arsenic TMDLs have been developed for Sevenmile Creek (see Volume II, Section 3.3 and Appendix A).

17. **Comment:** In reviewing the suspended sediment data for Sevenmile Creek that were included in the Volume I report, the extreme amount measured during the March 2003 flooding event seems to have skewed the statistics regarding the suspended sediment concentrations. We are not suggesting that Sevenmile Creek is not impaired due to sediment, but limited sampling from the stream during one flooding event should not be the deciding factor in those decisions.

    Response: We acknowledge that the suspended sediment data were skewed due to the presence of extreme values associated with a large scale flood event. However, the sediment impairment determination for Sevenmile Creek was based on a weight-of-evidence approach that considered other data types, including channel measurements, inter-gravel fine sediment concentrations, macroinvertebrate and periphyton community structure variables, fish populations, and a sediment source survey. All of the available data supported a conclusion that sediment related impairments are present in Sevenmile Creek.

18. **Comment:** Evaluation of lower Tenmile Creek for siltation and sediment problems relied on channel surveys from two field investigations near the confluence with Sevenmile Creek and above Green Meadow Drive. These sites are located within a mile of each other or closer, and are in the center of a 16-mile long reach. The high degree of variability present within this reach raises questions about the appropriateness of making reach-long determinations based

on limited sampling data. This comment can be extended to many other stream segments in the watershed that have limited sampling and field data.

Response: Data limitations are a common occurrence in Montana's water body assessment process, given the thousands of miles of streams and hundreds of thousands of lake acres. For this reason, many waters have not yet been assessed.

DEQ begins the stream assessment process by delineating separate reaches or segments along a stream. These are based on a number of considerations, including stream order/size, adjacent land uses, water quality classifications, the level of water quality, and the presence of impairment sources. As more data become available over time, these reach delineations are refined to represent more homogeneous segments.

In the case of Tenmile Creek, a large amount of water quality data is available for the stream as a whole, but the spatial coverage tends to be somewhat patchy. To be conservative (i.e., protective of water quality) it was decided to consider the stream impaired due to sediment.

19. **Comment:** Reference stream data from other areas of the state were used to establish nutrient concentrations and other stream criteria for Tenmile Creek. The use of these reference streams, and of small data sets in general, may not be appropriate. While we may hope to achieve an undisturbed or minimally disturbed status in the upper reaches of Tenmile Creek, it is unlikely that the Helena Valley with its (increasing) population of 45,000 people can attain such goals.

Response: Attainment of water quality standards and full support of designated beneficial water uses, as defined in the Montana water quality standards, are the end goals of the TMDL process. These uses include coldwater fisheries and associated aquatic life, waterfowl and fur bearers, body contact recreation, drinking water, and agricultural and industrial water supply.

It is clear from the Volume I assessment that these uses are not presently fully supported in Tenmile Creek. Population growth and urban impacts are contributing factors that will need to be addressed in the restoration plan. We cannot lower our water quality expectations for Tenmile Creek merely because of local population trends and land use intensity.

20. **Comment:** Stormwater runoff from numerous subdivisions and two incorporated towns is certainly a contributing factor to surface water quality in the Lake Helena watershed area and is a frequent source of water quality complaints. However, Volume I does not cite any stormwater sampling results including those contained in the "Total Maximum Daily Load Development (TMDL) and Assessment of Wetland Treatment of Stormwater Runoff for the City of Helena, Montana" (WQPD, 1999).

Response: We concur that urban stormwater runoff is a potentially significant source of nutrients, sediment, metals and other pollutants in the Lake Helena watershed. The relative importance of this source category in each of the water bodies considered in Volume II is presented in the tables in Appendix A.

21. **Comment:** We are somewhat fearful of the program that appears to be developing. While the science behind the restoration plan is important, it is vital to acknowledge the role of local community. EPA addresses this in nationally released documents and on their website, but the exclusion of public input during the development of the Lake Helena Volume I report would indicate this is not a priority and that stakeholders will continue to see the creation of rules and regulations for goals that are most likely unattainable, ineffective and unaffordable.

Response: The Lake Helena project team has expended a considerable amount of effort in providing opportunities for public participation. These efforts are described in Volume II, Section 5.0.

22. On a local level, we are bracing for compliance with complex and expensive programs like the Phase II stormwater requirements and the Groundwater Rule for 50 small public water systems. Implementation of these programs may ultimately drive some small water systems and communities to the brink of bankruptcy. The local municipalities make high-profile "end-of-pipe" targets and often bear the bulk of the responsibility, but they too face severe fiscal restraints. These are important programs and our resources are already directed at dealing with them. To add a new and potentially unachievable water quality program based on the use of rather small data sets and an unproven protocol of using reference reaches does not seem prudent.

Rather than investing resources in setting unreachable targets and then trying to achieve them, we propose a comprehensive, long-term watershed management approach that balances technologically feasible solutions with the economics of the region. We would propose a locally driven program that includes all stakeholders, with the goal of developing sustainable use of water resources for growing communities.

Response: This comment is addressed in Volume II, Section 4.0.

23. **Comment:** As you proceed with Lake Helena planning process, we urge you to support funding for public education, which is critical to changing behaviors that cause pollution of surface and groundwater. We strongly support the investment of resources in both broad-based and targeted education programs for residents. Targeted educational programs should be developed for the development community. State and federal support must be provided to local government as it struggles with increasingly difficult growth and planning issues. We believe that water quality protection begins with the way we use our land rather than in setting

goals that try to mimic conditions that exist in dissimilar and sometimes pristine settings.

Response: We wholeheartedly agree that a strong public educational component and adequate implementation funding will be key to the success of the Lake Helena water quality restoration plan. We look forward to working closely with the local watershed groups and the water quality protection district, and all watershed stakeholders, to develop a plan that is both implementable and effective at restoring and maintaining water quality. See Volume II, Section 4.0.

Volume II Response to Comments

The formal public comment period on the draft Lake Helena Watershed Water Quality Restoration Plan and TMDLs extended from December 27, 2005 to February 28, 2006. Eight parties or individuals submitted formal written comments. Responses prepared by EPA and DEQ follow each of the individual comments. The original formal comment letters and tape recordings of the two public meetings have been archived at the Montana DEQ offices in Helena.

1. **Comments:** The City of East Helena is opposed to the preliminary TMDL nutrient limits for Prickly Pear Creek because it will cause undue burden on the city and its residents. East Helena constructed a new treatment facility in 2003 at a cost of $4 million dollars. The design for the new plant was reviewed and approved by MDEQ with no mention that it may not meet future treatment requirements such as nutrient removal. Modifying the plant to accommodate nutrient removal would cost an additional $2 to $4 million, would need to be borne by the city's ratepayers, and would affect the city's ability to grow and prosper.

   Response: The wastewater discharge from the City of East Helena comprises 17% and 7% percent of the total nitrogen and total phosphorous loads, respectively, to Prickly Pear Creek. At the Prickly Pear Creek Watershed scale, it has been determined that TN and TP loads will need to be reduced by approximately 80 and 87 to attain full beneficial use support in Prickly Pear Creek and to ensure that water quality does not degrade further in Lake Helena and Hauser Lake. Not only do current TN and TP loads need to be reduced to attain water quality standards, but loads will need to be maintained at reduced levels to ensure that water quality standards are met in the future as well. This is especially important given the rapid pace of population growth in the watershed.

   The fact that there will be increased costs associated with population growth cannot be avoided. In recognition of the potential economic impact and uncertainty, a phased wasteload allocation approach has been proposed for the City of East Helena (see Appendix I) providing the City with approximately eight years to: 1) conduct facility optimization and feasibility alternatives studies, 2) conduct the necessary engineering design, 3) implement necessary facility changes/upgrades, and 4) raise funds to cover the costs of the necessary upgrades. Further, it should also be noted that adaptive management will be relied upon throughout the permitting process to ensure that limits are based on:

   - The best available data,
   - Attainable based on technology, and
   - Economic feasibility.

2. **Comment:** East Helena is currently considering accepting wastewater from several additional developments and proposed subdivisions. Increased sewer rates may dissuade developers from connecting to the city sewer and could lead to additional septic systems. Septic tank effluent is the largest source of nutrient discharges to Prickly Pear Creek, according to information presented at the Lake Helena TMDL public meeting. This nutrient source is unlikely to be decreased in the future since improved treatment can only be accomplished on a voluntary basis.

   Response: The two largest anthropogenic nitrogen sources for Prickly Pear Creek are effluent from municipal wastewater treatment facilities and septic systems. Municipal wastewater treatment facility effluent is the largest anthropogenic source of phosphorus, followed by agriculture. We agree that both wastewater treatment facility discharge and septic systems (and all non-point sources) will need to be addressed to attain and maintain water quality standards.

   Additionally, when considering acceptance of wastewater flows from additional development and proposed subdivisions, it is recommended that this only be done after conducting a watershed scale analysis in which it is determined to result in improved water quality conditions. At current treatment levels for the City of East Helena (3.6 mg/l and 23.2 mg/l for TN and TP), routing subdivision wastewater through the treatment facility may actually result in poorer water quality in Prickly Pear Creek than that which may be achieved with septic systems. As stated in Section 4.5.4: "*It is imperative...that future decisions regarding land use changes be made with full knowledge and understanding of future water quality implications. It is also imperative that cumulative effects are considered and all actions are evaluated at the watershed scale.*"

   Finally, while TMDLs are not self implementing and there are currently no regulatory controls specifically in place at the state or federal level to require implementation of non-point source controls, counties and other local units of government are urged to put zoning regulations, policies, or guidelines in place to direct future growth such that water quality standards can be attained and maintained.

3. **Comment:** Lastly, the nutrient effluent limits proposed in the Lake Helena plan for the East Helena wastewater treatment plant are not achievable by current technology.

   Response: Feasibility and alternatives analyses are proposed in Phase I of the phased wasteload allocation for the City of East Helena to determine what is, or is not achievable in light of technological and economic constraints (see Appendix I).

4. **Comments**: Several minor inconsistencies were noted in the Lake Helena document. The Helena Valley Irrigation District is identified as a source of sediment loading to Lake Helena, but Lake Helena is not identified as sediment impaired water body nor is a sediment allocation established. Data or other information should be included in the report to substantiate this conclusion.

   Response: The December 30, 2004 Impairment Status Report (MDEQ, 2004) concluded that there is currently insufficient data to make a sediment impairment determination for Lake Helena. Funding has been procured to collect additional data starting in September 2006. However, it is recognized at this time that there are anthropogenic sediment loads in the Lake Helena watershed, and some of those loads may be impairing beneficial uses in Lake Helena itself. Anthropogenic sediment loads, including sediment from the Helena Valley Irrigation District, should be considered in the future as part of the phased approach for attaining and maintaining sediment water quality standards in Lake Helena.

5. **Comment:** The Lake Helena report should make a clearer distinction between the Helena Valley Irrigation District and agriculture in general as sources of impairment in Lake Helena. It is unclear why the irrigation system is identified as a source of nutrients, both as an individual entity and an agricultural entity. Nutrient inputs to Lake Helena are likely to be the result of irrigation runoff and return flows resulting from on-farm practices. Voluntary on-farm soil testing to match nutrient needs with application rates would be the likely one means of reducing nutrient inputs into the system. This is likely to be clarified through future monitoring and adaptive management.

   Response: Agriculture and the system of canals and ditches associated with the Helena Valley Irrigation District were treated separately by the GWLF model used to estimate pollutant loads. GWLF specifically calculates nutrient loads from precipitation/runoff from agricultural land, but, does not directly consider any water/loads from irrigation. Irrigation loading, then, is considered separately in the model. A summary description of all of the source categories (e.g., Helena Valley Irrigation District, agriculture, forest harvest, etc.) has been added to Appendix C in the final document.

6. **Comment:** The Bureau of Reclamation is interested in participating in the implementation phases of the Lake Helena plan, including formal watershed meetings, education and outreach programs, and adaptive management decision making.

   Response: As stated in Section 4.0, "*there are 11 unique sources that will need to be addressed and 24 watershed stakeholder groups/entities that will likely need to participate to effectively implement this plan*". We support and encourage the participation of all watershed stakeholders.

7. **Comment:** MDT has no comments at this time.

   Response: Comment acknowledged.

8. **Comment:** The report ignores efforts made by local entities to improve water quality.

   Response: We disagree. We strongly support local efforts to improve water quality and suggest in the Conceptual Implementation Strategy (Section 4.0) that the only means by which water quality standards will be attained and maintained is through a collaborative, watershed scale effort including and involving all watershed stakeholders. While it is acknowledged that a number of measures have been implemented at the county and local level to protect water quality, the most recent water quality data and information available suggest that the subject water bodies are currently impaired and conditions will likely degrade further if additional measures are not employed to reduce, and maintain reduced, levels of pollutant loading.

9. **Comment:** The report provides no financial support for local governments to increase water quality protection efforts.

   Response: As summarized in Table 2-1 (from Section 2.0 of the document and shown below), a phased approach has been developed for establishment of the TMDLs and their implementation.

Table 2-1

2003 – 2004	2005	2006 →
Phase I – Information Gathering	**Phase II - Planning**	**Phase III – Proposed Implementation**
• Developing an understanding of the water quality problems. • Determined which water bodies needed TMDLs. • Solicited public comments. • Completed Volume I	• Revised some of the conclusions reached in Volume I based on public comments. • Identified the pollutant sources and relative importance of each. • Established water quality goals • Developed a pollutant load reduction plan to attain the water quality goals. • Completed Volume II	• Implement a coordinated effort at the watershed scale to reduce pollutant loading from both point and non-point sources. • Conduct follow-up and/or supplemental studies to address uncertainties identified in previous phases. • Revise, adjust, and manage adaptively as appropriate based on new information.

This document provides a framework plan for restoring water quality in the Lake Helena Watershed. Implementation of the plan and securing funding for implementation are the next steps and are above and beyond the scope of this document. However, once implementation is initiated, there are a number of sources of funding through EPA, DEQ and other sources that may be available to support locally lead water quality restoration efforts. Finally, this is a watershed scale problem that is having an affect on all watershed residents. Attaining and maintaining water quality standards and a high quality of life for residents within the watershed will ultimately be the responsibility of all affected units of government as well as all of the residents with the watershed.

10. **Comment:** The report provides no regulatory support for local governments and will fail to improve water quality in the watershed by failing to regulate non-point sources.

Response: It is a fact that neither the federal Clean Water Act nor the Montana Water Quality Act provides a regulatory mechanism for requiring implementation of non-point source control measures. The document does, however, clearly point out the various sources and causes of water quality problems and provides direction regarding what needs to be accomplished to achieve water quality standards. Given the current regulatory framework, success or failure of this plan will be determined by the watershed stakeholders. As mentioned in the response to comments # 2, counties and other local units of government are urged to put zoning regulations, policies, or guidelines in place to direct future growth such that water quality standards can be attained and maintained. It should be noted that we will provide technical support, as requested and appropriate, regarding any local efforts to develop effective policies or guidelines to protect water quality.

11. **Comment:** This plan targets sources that are in compliance while ignoring those sources which may contribute the greatest share.

Response: We disagree. This document and TMDL process targets all sources that likely contribute a controllable pollutant load. For example, quantified load reductions are proposed for phosphorous for the following source categories in Prickly Pear Creek:

1. Current timber harvest
2. Dirt roads
3. Non-system roads
4. Paved roads
5. Urban areas
6. Anthropogenic streambank erosion
7. Abandoned mines
8. Septic systems
9. Agriculture
10. Point source discharges

A similar comprehensive consideration of sources was applied to all other water bodies and pollutants addressed in this document.

12. **Comment:** Acknowledgement within the plan of deficiencies in the presently available data suggests that the plan is based on inadequate information and requires regulated entities to invest money in collecting the needed information without any provisions for funding. We are not convinced that investments need to be made in continued studies, but instead favor on the ground projects and enforceable development regulations that are more protective of water quality. For example, the agencies could provide funding to Lewis and Clark County for the implementation of a county wide septic system maintenance program.

    Response: As mentioned in comment # 9, funding may be available for locally lead water quality restoration efforts. We recommend contacting Robert Ray with the DEQ Water Quality Protection Section to explore funding options for on-the-ground projects. Regulations are discussed above in Comment # 10.

13. **Comment**: The natural reference condition for Lake Helena was as a wetland. Table 38 on page C-58 of the Lake Helena plan indicates that wetland acreages were the same historically as presently when considerably more wetland acreage was present in the natural condition. Also, the extent of historic wetlands most likely provided a higher level of treatment to water leaving the Helena Valley and entering the Missouri River than we see today. Table 38 should be amended to reflect the loss of wetlands, and existing and natural acres of water should be modified to reflect less water in the past than exists now.

    Response: In accordance with MCA 75-5-306 the term natural: "*refers to conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams at July 1, 1971 are natural.*"

    The earthen causeway and control structure (i.e., dam) impounding Lake Helena was constructed in 1945. In accordance with MCA 75-5-306, conditions that may have existed prior to construction of the dam are no longer considered natural.

14. **Comment:** Paving roads reduces but does not entirely eliminate sediment, nutrient, and metals contributions to streams. Paved roads should be included as an anthropogenic source category for sediment loading to streams similarly to how it is treated as a nutrient source category. Paved roads could be included as a component of the "urban area" source category but this is not clearly stated.

    Response: Paved roads were included as a sediment source, but the relative contribution from this source category is so low that it is insignificant compared to other sources (often less then 0.1% of the load). For this reason, paved roads were not included in the sediment TMDL tables. As noted in the response to

Comment # 5, a summary description of all of the source categories (e.g., paved roads, urban, Helena Valley Irrigation District, agriculture, forest harvest, etc.) has been added to the final document.

15. **Comment:** The stated assumption that no BMPs are currently in place for unpaved roads is incorrect, although we agree it is not realistic to expect that all BMPs will be employed and routinely maintained on a watershed-wide basis. Paving is planned for the Marysville and Rimini Roads, while other areas like Skelly Gulch are not maintained. BMPs have been put in place in numerous areas, including riparian planting projects on upper and lower Tenmile Creek, construction BMPs associated with new roads and subdivisions, and stormwater management requirements for subdivisions and the City of Helena.

    Response: While it is acknowledged that BMPs have been employed in many areas for many source categories, to be conservative and in the absence of site specific data regarding each individual source, it was assumed that no BMPs are currently in place. This assumption provided a means to estimate the maximum level of pollutant load reduction that could potentially be achievable.

    Volume II is intended to provide pollutant load reduction targets or goals at the watershed scale. In other words, it is intended to answer the question: By how much do pollutant loads need to be reduced to attain water quality standards? The specific means by which these goals will be achieved will need to be determined as one of the first steps in implementing this plan. In simple terms, for each source category (e.g., unpaved roads), the first step would involve an inventory/evaluation of existing BMPs to determine what additional control measures would need to be employed.

16. **Comment:** The Helena Valley Irrigation System is a source of sediment resulting from Helena and East Helena stormwater discharges to the canal during high runoff events. Table 3-2 should be amended to reflect this source of sediment loading.

    Response: See response # 4.

17. **Comment:** Streams in the lake Helena watershed are subject to frequent flooding and associated streambank erosion. Is streambank erosion considered under anthropogenic or natural background sediment source categories? Flood events should be specifically included under one of these source categories in Table 3-2.

    Response: Streambank erosion is a natural phenomenon. However, human-caused increases in water yield (e.g., flooding resulting from increased impervious areas), stream channel modifications, riparian degradation and other human influences can cause and/or exacerbate stream bank erosion. As described in Appendix D, observed stream bank erosion was stratified into two categories (natural or human-caused) to focus future implementation efforts on anthropogenic stream bank erosion.

18. **Comment:** Interim nutrient targets are appropriate for Lake Helena since it was historically a wetland. The loss of these wetlands and the resulting effect on water quality should be considered in the development of Lake Helena nutrient targets. This could be accomplished through modeling and the information could help justify the need to protect and expand existing wetland acreage.

    Response: See the response to comment # 13.

19. **Comment:** Efforts to resolve the nutrient problem in Lake Helena should include a reexamination of the non-degradation and mixing zone regulations administered by MDEQ. Unless non-point sources receive more attention in the Lake Helena plan, water quality will continue to degrade. The focus on point source controls does not adequately address the problem.

    Response: The document and associated TMDLs do not focus on point source controls. Pollutant load reductions are proposed for all significant sources (see response to comment # 11). However, we do agree that both point and non-point source load reductions will be necessary to attain and maintain water quality standards.

20. **Comment:** We agree with the assessment of the metals problem in the Lake Helena document and support a top-down metals allocation approach for mining related sources. The Lewis and Clark Water Quality Protection District will continue to provide public education about non-mining related anthropogenic sources of metals.

    Response: As mentioned in our response to comment #6, we support, encourage and appreciate locally lead water quality restoration efforts.

21. **Comment:** Discussion of attaining and maintaining state water temperature standards for Lake Helena watershed streams must address the dewatering issue. Can we effectively set temperature targets for streams when we have no control over streamflows? Should we focus our efforts on other TMDL issues until the water rights adjudication process is completed? Are there certain reaches of Prickly Pear Creek that we should prioritize at this time? Please consider adding language to the discussion on temperature problems that addresses inadequate construction setbacks to streams in urban areas as a source of temperature impairment. Lewis and Clark County has building setback requirement along streams but the City of Helena does not. When properties are annexed, there are no controls over what can happen on the banks of streams. Vegetation can be stripped and replaced with lawns.

    Response: As stated previously, this is a "framework" water quality restoration plan in which the sources and causes of water quality impairment have been identified and water quality goals have been defined. This plan is intended to be a starting point for water quality restoration. We feel that it is appropriate to set temperature targets based on the best available information. However, it is fully recognized that neither the Clean Water Act nor the Montana Water Quality Act provides any regulatory means to address stream flows. Ideally, stream flow issues that may be contributing to increased temperatures will be addressed voluntarily. If, in the future, it is determined that stream flow issues cannot be addressed, the temperature targets may need to be revised.

22. **Comment:** In the discussion on Institutional Framework and Watershed Stakeholders on page 47, please add the following entities under Lewis and Clark County: Board of County Commissioners, Public Works/Roads, Water Quality Protection District, Lower Tenmile watershed Group, Prickly Pear Watershed Group, City-County Health Department, and Community Development and Planning. Also, the Lewis and Clark Conservation District is not affiliated with the county. Other stakeholders that should be involved with the restoration plan include: Montana Department of Transportation, ASARCO, Ash Grove Cement, Helena Sand and Gravel, and Montana Tunnels. Please add the Lewis and Clark Water Quality Protection District to the list of abandoned mines stakeholder list for addressing sediment and metals sources.

    Response: The stakeholders have been added.

23. **Comment**: EPA and MDEQ are identified as the lead agencies for addressing remaining data gaps. There is no alternative identified if funding doesn't materialize. Other interim methods of collecting data should be identified and provisions made for other agencies to assume the lead if necessary.

    Response: Funding for implementation of the tasks described in Section 2.0 of Appendix H regarding data gaps monitoring and assessment has been acquired and it is anticipated that work will begin in late 2006. Once contracts are in place, the first step will involve preparation of a detailed Sampling and Analysis Plan and coordination with watershed stakeholders.

24. **Comment:** Although TMDL effectiveness monitoring is the primary responsibility of MDEQ, the responsibility for a "much more thorough" assessment is passed to unidentified stakeholders. What level of assessment is required? Is it reasonable to spend money on assessment rather than on implementing BMPs, mitigating and restoring wetlands, and providing other support for water quality improvement?

    Response: The level of assessment required to determine beneficial use support is described in Appendix A of the 2004 Water Quality Integrated Report for Montana (DEQ, 2004). It is reasonable to spend money on effectiveness monitoring since that provides one of the only means of determining if implementation of the plan is successful. If such monitoring reveals that water quality goals are not being met, it also provides the necessary data for adaptive management.

25. **Comment**: Lewis and Clark County agrees with the discussion in the Lake Helena plan pertaining to future sources of pollution and the need to make future land use decisions with full knowledge and understanding of the water quality implications. We would like to see MDEQ pursue and support legislation addressing cumulative impacts through changes to the non-degradation and mixing zone regulations. At present, the regulations do not address cumulative effects except within individual subdivisions.

    Response: The premise behind this "framework" water quality restoration plan is to identify sources and issues that degrade water quality from a cumulative effects perspective and to address them at the watershed scale. MDEQ has not proposed any specific agency-sponsored legislation that would address cumulative impacts through changes to the non-degradation and mixing zone regulations. We are talking to stakeholders (cities, counties, developers, etc) about what types of legislation might effectively address some of the water quality issues in high growth areas of the state. Rule making may be another effective tool to address issues of growth, and the ongoing task force can help with this process. Although MDEQ is not drafting specific agency bills that address growth, the department may support bills introduced by others, and it is working closely with other agencies to provide support for and collaboration on their efforts.

26. **Comment:** Modeling tools are helpful in decision-making but can be misleading. Over-reliance on models is as questionable as using poor models. If we are to move to modeling as a water quality pollution prevention tool, the model should be reviewed and approved by the stakeholders that will be required to use it.

    Response: We agree and will provide a means for stakeholder review, involvement, and training as appropriate.

27. **Comment:** Lewis and Clark County has an existing GIS system with extensive modeling capabilities. This system should be evaluated for potential use that would allow local government to actively participate in water quality protection measures without reliance on other agencies that may or may not have adequate funding.

Response: Without first-hand knowledge or experience with the County's GIS system, it is not possible to respond directly to this comment. We would be happy to meet with County modeling staff to explore means by which the GIS tools could be used to their full advantage. However, it should be noted that the modeling tools used, and to be developed as described in the document have and/or will be specifically tailored and calibrated to Prickly Pear Creek and the Lake Helena Watershed. Further, it is envisioned that models developed by EPA or DEQ as part of this effort will be made available to watershed stakeholders as appropriate and training will be provided.

28. **Comment**: The approach outlined in the Lake Helena plan implementation phase is fragmented and is inconsistent with the watershed approach concept. The size and diversity of the proposed Lake Helena watershed oversight committee will lead to fragmentation of the process and divides responsibility for water quality improvements among too many agencies. There is a need for a strong state role, which is not addressed in the plan.

Response: We believe that the very premise of this watershed scale plan is to address the fragmentation concern. The plan addresses all pollutants and significant sources contributing to the impairments of beneficial uses in the subject water bodies. It also recognizes and acknowledges the need for issues to be addressed at the watershed scale, which in turn results in the involvement of a diverse and vast group of stakeholders. This approach is no different than the "watershed group" approach currently applied to this and other watersheds across Montana. Established watershed groups share the goal of this plan to achieve water quality. This plan, however, goes a step further and sets specific goals and targets that will specifically attain and maintain State Water Quality Standards.

Finally, MDEQ believes that all governmental entities have a role and a responsibility in the process. Federal agencies have the role of including a regional perspective, oversight of delegated authorities, and funding for programs and research. State agencies have the role to regulate and participate at the state level. Local governments have the role of governing at the local level, which in turn can result in site-specific practices. We acknowledge the limited resources of all entities, including the state. Therefore, it is imperative that collaborative efforts occur in setting priorities and addressing financial shortcomings. The watershed cannot achieve its water quality goals without collaboration among the various public and private entities.

29. **Comment:** We have some concerns with how the GWLF model was used to estimate the impact of septic systems on nutrient loading to surface waters. Septic system waste treatment efficiency can be quite variable depending on many factors, including density and lot sizes, soils, and system type. We have spent considerable time determining problem areas within our watershed. A septic maintenance program would address each site on an individual basis, rather than making assumptions at the watershed scale.

    Response: We agree that septic system treatment efficiency can be quite variable. However, without site-specific data for each failing system, assumptions were required (i.e., 7% failing, level of treatment, etc). As stated in our response to Comment #21, this is a "framework" water quality restoration plan intended to be a starting point for water quality restoration. We feel that the methods employed to estimate the relative importance of nutrient loading from septic systems are adequate/appropriate, especially at the watershed scale. This plan is intended to point out and put into perspective the water quality problems and sources at the watershed scale. Site specific details will need to be worked out during the next phases of this effort (i.e., implementation).

30. **Comment:** The Lake Helena plan acknowledges the need for more accurate GWLF model input numbers for the number of septic systems in the watershed. Lewis and Clark County is committed to improving our understanding of the numbers and condition of systems in this county. However, state commitment to obtaining this information on a statewide basis is necessary for this to occur in the upstream Jefferson County portion of the watershed. Again, a strong state role is suggested.

    Response: We agree that the information described in comment 30, is vital to the success of the plan. We also acknowledge that similar information is needed throughout the state, but especially in the high growth areas where groundwater is most likely to be impacted by development. As previously stated, limited resources and priorities are real issues that need to be addressed. The state needs to better understand the impacts of septic systems on groundwater in areas like the Helena Valley, and as funding allows, DEQ will update the model as more data becomes available.

31. **Comment:** Septic systems are indicated as a major source of nutrient loading in the watershed yet they are targeted for a 0% reduction in the allocation strategy. These systems are permitted in accordance with minimum standards set by MDEQ. A statement in Volume II of the Lake Helena plan (Appendix A, p. A-119) indicates that citizen education pertaining to proper septic system operation and maintenance will likely reduce phosphorus and bacterial loading from septic systems, but nitrogen reductions are unlikely because even properly functioning septic systems have poor nitrogen removal. If this is true, these systems are failing to protect the quality of surface and groundwater and MDEQ should develop alternative standards for on-site wastewater systems that do protect this resource.

Response: In response to this, and several other comments, considerable additional work has been completed relative to septic systems. A new technical appendix (i.e., Appendix K) has been prepared in which the state and county septic system regulations and the available literature regarding the pollutant removal efficiency of conventional and "alternative/enhanced" septic systems have been summarized. The information in the technical appendix was then used to reevaluate the allocations (i.e., load reduction targets) for septic systems presented in Appendix A.

In spite of all of this additional focus on existing septic systems, the conclusions haven't changed substantially. Previously, it was assumed that fixing the failing septic systems in the Lake Helena Watershed would not result in any (i.e., 0%) reduction in the overall total nitrogen (TN) load. Based on further analysis, it has been estimated that repairing all of the failing septic systems in the Lake Helena Watershed such that they meet current design standards for conventional septic systems would only reduce the overall TN load from septic systems by 0.5 percent. At the scale of the Lake Helena Watershed, this reduction in septic system TN load would only result in a net, watershed scale load reduction of 0.1 percent. Even if all of the failing septic systems were replaced with "Level 2" (enhance treatment) systems, the overall TN load from septic systems would only be reduced by an estimated 1.7 percent. Again, at the Lake Helena Watershed scale, the net affect would be negligible (i.e., the overall TN load would only be reduced by 0.5 percent if all the failing systems were replaced with Level 2 systems).

Based on the literature, the treatment efficiency for nitrogen from conventional septic systems is poor with typical effluent concentrations of approximately 60 mg/l TN. As a result, merely repairing/replacing the failing systems with conventional systems will not have a significant affect on water quality. Even enhanced treatment systems (i.e., "Level 2") result in relatively poor nitrogen treatment (2 to 60 mg/l effluent TN concentration. See Appendix K).

In the end, with the exception of connecting the existing septic systems to a wastewater treatment facility (with advanced treatment for both nitrogen and phosphorus), there is little that can be done to reduce loading from existing septic systems significantly. Even this potential solution should only be considered after the cumulative effects are considered at the watershed scale. It is not a "given" that municipal wastewater treatment is superior to that which can be provided by septic systems.

Finally, while addressing current nutrient loads from the existing septic systems presents a challenge, proper land use planning and local regulation can easily address potential adverse impact from **future** septic systems. As stated in Section 4.5.4: *"It is imperative…that future decisions regarding land use changes be made with full knowledge and understanding of future water quality implications. It is also imperative that cumulative effects are considered and all actions are evaluated at the watershed scale."*

32. **Comment:** Wastewater lagoons are treated in the Lake Helena plan as point sources (Appendix E, p. E-9-10) but are not permitted under the NPDES system. The plan identifies lagoons as sources of nutrients and one lagoon in the Helena Valley has received notification of water quality violations for leakage. While MDEQ approved the original construction of these lagoons, it does not currently permit, regulate or monitor their performance or ongoing maintenance. These sources are assigned a load reduction of 0% even though the problem has been acknowledged for years and few if any improvements have been made to these problem systems. The county believes the Lake Helena plan should address this situation by allocating a load for this source category.

Response: Nutrient loads from lagoons were included in the Prickly Pear Creek and Lake Helena nutrient TMDLs as part of the "point source loads." Additional language has been added to the tables in Appendix A to clarify this issue. Therefore, the necessary point source load reductions apply to both lagoons and municipal facilities. Nutrient load reductions (i.e., allocations) have been added for Treasure State Acres, Tenmile and Pleasant Valley Subdivisions, and Leisure Village Mobile Home Park lagoon facilities. Lagoon load reductions were not further discussed in the report because: (a) they are a very small percentage of the pollutant load (e.g., 0.6% of the TN load for the entire Lake Helena Watershed - see Appendix A, Table 6-5 and 6-7), and (b) there is no regulatory authority to require reductions under the MPDES or TMDL programs. Lagoon inspections and enforcement are coordinated through several departments at MDEQ including the Enforcement Division, Water Pollution Control State Revolving Fund, and the Planning, Prevention and Assistance Division. For example, at the time of this report, the Montana DEQ Enforcement Section is investigating the Tenmile/Pleasant Valley Lagoons because of excessive leakage from the system. It is anticipated that lagoon load reductions identified in this report will be achieved through coordination with the appropriate Montana DEQ divisions and watershed stakeholders.

33. **Comment:** The Lake Helena plan lists channel encroachment or sinuosity reduction related to transportation infrastructure as a primary cause of sediment from eroding stream banks. This includes interstate highways, city/county roads, forest roads, and railroads. The Montana Department of Transportation and the railroads should be listed as stakeholders in the Lake Helena plan and held equally accountable for addressing some of these problems.

    Response: The Montana Department of Transportation and Montana Rail Link have been added to the list of watershed stakeholders.

34. **Comment:** Various models, assumptions and reference reach approaches were used to develop numeric targets and load estimates for sediment. The discussion of these techniques in Appendix D raises questions about the precision of the targets and allocations. Since TMDL allocations for individual (point) sources must be incorporated into NPDES permits, we believe these methods and the lack of precision in the targets and allocations are inappropriate.

    Response: Although there is uncertainty in each of the individual components of the analysis, when combined in a weight of evidence approach, we feel that the conclusions reported in this document are adequately supported. Further, uncertainty has been acknowledged throughout the document, and a follow-up monitoring strategy and an adaptive management approach have been developed to address the identified uncertainties.

35. **Comment:** It is not possible within the context of this plan to understand how streams in the Lake Helena watershed have adapted to the loss of wetlands, infringement of floodplains, removal of beavers, and restriction of channel migrations due to human settlement over the past 150 years. Methodologies used in the plan employ gross assumptions, including the assumption of no current BMPs, "coarse filters", and admitted over- and under-estimations to justify targets. These should not be used as anything but guidance in the process to address sediment and nutrient impairments.

    Response: See response to comment # 34.

36. **Comment:** I would like to see specific data included in the plan that addresses groundwater pollution from the Treasure State Acres and Tenmile Estates/Pleasant Valley sewage lagoons and its overall effect on nitrogen and phosphorus loading in Prickly Pear Creek. The lagoons are severely out of compliance and are contaminating the groundwater. Monitoring wells placed around these lagoons would provide information on groundwater contamination and potential loading to Prickly Pear Creek

    Response: See response to comment # 32.

37. **Comment:** Table 3-2 of the Lake Helena report outlines a proposed sediment load reduction approach for urban areas that includes BMPs for lawn fertilizer applications. The logic is not clear and this seems more relevant to nutrient rather than sediment controls.

    Response: The reference to lawn fertilizers in Table 3-2 was an error. This has been corrected.

38. **Comment:** The projected average removal efficiency of 80% for BMPs aimed at controlling sediment and metals loading does not take into account or give credit for BMPs already implemented by Helena's stormwater utility for purposes of preventing sediment and metals from entering streams.

    Response: At the time of this report, no data or information were available regarding the pollutant removal efficiency of Helena's storm water system. The extent to which the system is functioning from a water quality perspective is unknown at this time. To be conservative, it was assumed that no BMPs are in place (i.e., it is better to assume no treatment than to assume that the levels of treatment are adequate when there is no data or information).

    Appendix J has been added to the final document in which stormwater permitting is discussed. The City of Helena stormwater systems is currently authorized to discharge under Montana's General Permit for Small Municipal Separate Storm Sewer Systems. With the exception of a recommendation to evaluate the pollutant removal efficiency of the storm sewer system, this TMDL does not impose any requirements upon the City of Helena regarding stormwater management at this time. This TMDL recognizes and supports the efforts that will be implemented under Montana's General Permit.

39. **Comment:** Fort Harrison is listed in the Lake Helena plan as a point source for nutrients. What load was calculated for this source? Fort Harrison has been connected to the City of Helena wastewater system since 2002.

    Response: No loads or reductions were calculated for the Fort Harrison lagoons. Data from the lagoons were only used to calibrate the GWLF model for conditions and data collected prior to 2002.

40. **Comment:** The component nutrient loading from septic systems in the Lake Helena plan does not reflect waste from septic tank pumping received by the City of Helena wastewater treatment plant. The contribution of nutrient loading to Lake Helena watershed streams should be revised upwards in the plan and the city's contribution revised downward to reflect this practice. If the city is required to provide and pay for additional nutrient loading reductions at the wastewater treatment plant, and it is not given credit for treating waste generated outside the city limits, it will have to consider discontinuing this good neighbor practice.

Response: We agree that uncontrolled increases in septic system loading will result in an increased burden on the City's wastewater treatment plant. That is why we stated: *"It is imperative that cumulative affects are considered and all actions are evaluated at a watershed scale"* (see Section 4.5.4).

The concept of "credit" is not especially relevant in this phase of the TMDL process, but may become important in the future when this plan is implemented. This was addressed in Figure 3-1 of Appendix I, where future increased loading from point sources may be allowed if it is demonstrated that it results in a net-watershed scale nutrient load reduction (i.e., "trading").

Also, an alternatives/feasibility analysis is recommended in Appendix I. It is recommended that the fate of septic system sludge be one of the issues considered in the alternatives analysis.

41. **Comment:** We believe that the nutrient targets proposed for the Lake Helena streams are too low. They were arbitrarily selected based on low order streams located high in the watershed. We appreciate the proposed adaptive management approach by which the targets may be adjusted in the future. However, we feel it's in everyone's best interest to set realistic and achievable targets at the outset.

Response: The targets that have been selected are based on the best data and information currently available and are being implemented as interim targets. They were independently derived by two separate studies based on review and evaluation of available reference stream information. These interim nutrient targets will not be enforced and will not be used directly in establishing MPDES permit limits. However, they are intended to provide a starting point (based on the best information currently available) for nonpoint source reductions and may be revised based on the alternative analysis/feasibility study for point source dischargers recommended in Appendix I.

42. **Comment:** The nutrient reduction goals give every appearance that point source dischargers, and the City of Helena in particular, are targeted to compensate for the lack of expectation that anything can be done about non-point sources.

Response: The City of Helena is not being targeted for the lack of expectation that anything can be done about non-point sources. Rather, the City of Helena's wastewater treatment discharge represents the largest non-natural source of both phosphorus and nitrogen to Prickly Pear Creek. The estimated maximum attainable load reductions are proposed for all potentially significant nutrient sources in the watershed, not just the City of Helena (see Table 8-7 and 8-8, Appendix A). For example, the TMDL recommends 97 percent nutrient reductions from timber harvest, 60 percent reductions from dirt roads, 90 percent reductions from anthropogenic streambank erosion, and 90 percent reductions from agriculture. Further, in recognition of the fact that the City's discharge will be regulated under the MPDES permit system and upgrades may have an economic impact, we: 1) developed a phased approach providing the City with approximately 8 years to comply with water quality-based limits; 2) provided opportunity for the City to have input on the final limits based on the results of alternatives analyses and feasibility studies, and; 3) featured adaptive management to facilitate increased loading if it can be demonstrated that it will result in a net, watershed-scale nutrient load reduction.

43. **Comment**: The Lake Helena plan indicates that both point and non-point source nutrient reduction measures should be implemented immediately. This is inconsistent with Table 6-4 in Appendix, A which allocates a load reduction for septic systems, (the largest contributor of nitrogen to Lake Helena) at 0%.

    Response: Nitrogen loads from septic systems have been revised in Appendix A. See response to comment # 31.

44. **Comment:** The actions requirements of Phase I, II, and III of the nutrient reduction strategy place all the burden for solving water quality issues on point source dischargers and ignore the greater combined impact of non-point sources. As such, the plan is unworkable.

    Response: We disagree. As stated in our response to Comment # 42, the estimated maximum attainable load reductions are proposed for all potentially significant nutrient sources in the watershed, not just point sources (see Table 8-7 and 8-8, Appendix A).

45. **Comment:** The percent reduction targets for urban areas for metals appears to originate from the assumption that 80% sediment removal efficiency can be obtained with the application of BMPs. This assumption does not give credit for the existing BMPs that the City of Helena already has in place for collecting sediment and metals in stormwater detention/treatment facilities.

    Response: See response to Comment # 38.

46. **Comment**: If the state wishes local governments to fund and regulate TMDL implementation efforts, then the state needs to empower local governments through appropriate legislation that enables new taxes and fees, full land use regulatory authority, and the ability to create special districts for environmental improvements that cannot be defeated by property owner petition. If MDEQ is to assume a lead role in the proposed TMDL implementation stakeholder group, an equal commitment for funding and regulatory authority targeting both point and non-point sources will be needed to ensure success in this endeavor.

    Response: We believe that local governments are already empowered to require restrictions that deal with many of these issues at the local level. Currently, MDEQ can only impose such restrictions on a statewide level. The problem is that many issues are local in nature and require local solutions. What works in Helena, may not work in Plentywood. Therefore, proactive approaches at the local level are often more realistic and achievable than statewide solutions. However, the Department is working with other state agencies on draft legislation that may provide additional tools for addressing growth in Montana. Additionally, the Department is looking for ways to modify the current protocols by which we conduct subdivision approvals, in order to address the concerns raised in this comment. Finally, as stated previously, funding, or lack of it, remains an issue. MDEQ receives considerable support through federal funding, which has been consistently declining in recent years. The State Legislature has provided some additional support, but over the long term, adequate funding needs to be pursued at all levels.

47. **Comment:** Appendix A of the Lake Helena plan indicates that it may not be possible to attain the 80% TN load reduction. Since septic systems alone contribute almost 30% of the TN and no reductions are proposed for this source category, it is clear that the 80% load reduction will be impossible to achieve.

    Response: See response to comment # 31.

48. **Comment:** The rationale for the proposed metals reduction strategy is unclear. Abandoned mines are responsible for about two-thirds of the documented metals loading and the proposed metals reduction goal for this source category is 67.8%. At the same time, the reduction goal for metals loading from urban areas is 80% while this source category only accounts for 1% of the total.

    Response: As with nutrients, current metals levels are often so high that all sources will need to reduce loading to the maximum extent possible to attain water quality standards. The proposed reductions, therefore, are the estimated maximum attainable load reductions. For urban areas, the metals loads and reductions are also based on the required sediment reductions as described in the sediment TMDLs in Appendix A.

49. **Comment:** The load reductions assigned to existing lagoon systems is 0%. Given that several of these lagoons are leaking as noted in Appendix E and are under a compliance order by MDEQ, it seems inappropriate that no load reduction is assigned. Further, lagoon systems are prohibited by law and design standards from contributing loading to state waters, therefore their reductions should set at 100%, not 0% as shown in the Lake Helena plan.

    Response: See response to comment #32. Lagoon loads and load reductions were included in the TMDLs in Appendix A for the respective watersheds. Furthermore, Montana DEQ is currently taking action to address the lagoons at Treasure State and Tenmile/Pleasant Valley.

50. **Comment:** The anticipation of zero load reduction from septic systems and lagoons sets the stage for the continued propagation of rural small lot subdivisions. If these systems are not held accountable for any load reduction, then the burden for solving the problem falls almost entirely to the municipalities. Not only is this unfair, it cannot solve the problem due to the quantity of nutrient loading contributed by septic systems and the incentive this provides to continue the current land use practices.

    Response: See response to comment # 31.

51. **Comment:** The rationale for the proposed percentage reduction in loading from each point source is unclear. For example, the City of Helena wastewater plant is targeted for a 92% reduction, the City of East Helena facility is targeted for a 97% reduction, and the Tenmile Estates lagoon system is targeted for 0% reduction. For all point sources combined, the total proposed reduction is 88% while the goal is 80%. This means that point sources as a group are carrying the burden for septic systems, which are a non-point source. Within the point source group, only the municipalities are slated for reductions.

    Reductions in loading from septic systems can be achieved through a program of reasonable land, soil and water conservation practices, which MDEQ is required by law to support. Through education and voluntary measures, attainment of at least a 10% reduction from this source category seems entirely reasonable.

    Response: See response to comment # 31 and 32.

52. **Comment:** The Lake Helena plan indicates that the City of Helena stormwater system was not specifically accounted for within the watershed loading modeling exercises due to a lack of information. The city's 2003 Stormwater Master Plan is available as a reference and it describes the existing facilities and treatment structures. However, the city's stormwater computer model is limited by license and cannot be shared.

    Response: See response to comment # 38.

53. **Comment:** The units of measure in Table 13 of Appendix C are undefined. Is "g" intended to mean gallons, grams, or something else?

    Response: Grams. Table 13 of Appendix C has been modified in the final document.

54. **Comment:** The figures and conclusions presented in Section 2.4.6, Sewer System Expansion, in Appendix C are misleading and inaccurate. Given that a properly constructed septic system in good working order may produce a discharge containing 50 mg/L of nitrogen as compared to an average wastewater treatment plant effluent concentration of 7.7 mg/L, the net reduction achieved by converting

septic systems to centralized sewer is in the range of 84%, not 2.3% as stated in the report. This statistical manipulation of the data distorts the nutrient reduction potential of municipal wastewater treatment versus individual septic tanks and drainfields or failing community lagoon systems. The results also do not recognize the role of the city wastewater treatment plant in accepting septic tank maintenance waste.

Response: The above assumption does not take into account the volume of water discharged from each system – rather, only concentrations are considered. In our loading estimates from each system, we considered the number of people served, the per capita flow rate, and the discharge concentration. We did state that the reductions were conservative because 1) on-site system failure rates in the expansion areas are likely higher than the assumed 7% due to the small lot sizes and poor soils and 2) future upgrades at the WWTP may further reduce the TN concentration in the effluent. The results do inherently reflect the WWTP acceptance of septic tank maintenance wastes because we used the plant's DMR data to estimate the concentrations and loads from the plant. .

Also, see comment # 55 below.

55. **Comment:** The City of Helena has no plans to annex properties not currently served by city utilities, including the 5.3 square miles referenced in the Lake Helena plan. These decisions are at the choice of the individual property owner and under current policy unless the owner agrees to accept full municipal services and provisions for city standard infrastructure, the city likely would not be interested in annexation. However, the urban planning area for Helena includes areas well beyond the city limits. It is recognized that as population density in the outlying areas increases, there will be a demand for city services that may result in annexation.

    Response: Section 2.4.6 in Appendix C has been modified to feature a hypothetical sewer system expansion for demonstration purposes only.

56. **Comment:** The discussion pertaining to the City of Helena's stormwater permit in Appendices C and E of the Lake Helena plan is inaccurate. The city has applied for but does not presently have an MS4 stormwater permit (Appendix C). There is no present or past litigation between the city and MDEQ relative to stormwater permitting (Appendix E). Additionally, the comment that the city illegally discharges stormwater to the Helena Valley Irrigation Canal is wholly incorrect and mischaracterizes the problem Appendix E. In fact, the Davis Gulch drainage was truncated decades ago by the construction of I-15. This natural drainage has nowhere to go and backs up and overtops the irrigation canal during extreme runoff events.

Response: Appendix C and E have been amended to correct the inaccuracies. In addition, Appendix K has been added to the document, in which stormwater permitting is discussed.

57. **Comment:** The City of Helena has been proactive in addressing stormwater issues for many years. In 1988, Helena was one of the first cities in the state to develop a stormwater utility. In advance of NPDES regulations, Helena developed stormwater detention/retention facilities for flow and water quality control and implemented other best management practices for stormwater infrastructure.

Response: See response to comment # 38.

58. **Comment:** The City of Helena supports efforts to improve water quality in both surface and ground waters and we share your recognition and concerns of the many sources of pollution affecting our waters. While the Lake Helena report is a recommendation for future action and carries no regulatory elements, it is intended to guide future regulatory action, particularly those targeting point source generators.

Response: As stated in Section 4.0, "*there are 11 unique sources that will need to be addressed and 24 watershed stakeholder groups/entities that will likely need to participate to effectively implement this plan*". We support and encourage the participation of all watershed stakeholders. .

59. **Comment:** The implementation plan discussion in Chapter 3 suggests additional monitoring, studies and analysis by point source generators, as well as enhanced treatment and reduced load limits. For non-point source generators, little is offered except undefined voluntary measures. At present, the plan does not and cannot solve the problems it is intended to address.

Response: The current plan merely establishes the foundation and an overall framework for attaining and maintaining water quality standards. While the plan addresses the formal requirements of the TMDL process in the short term, the real work, and the ultimate success of the plan in restoring and maintaining water quality, lies in the future. Water quality problems in the Lake Helena Watershed are highly complex and result from more than a century of human development and a host of land use activities. Despite diligent planning and the application of pollution preventing measures, present water quality in the basin is changing as water and land uses change, pollution sources increase, and competition for the available water supply accelerates.

The ultimate ability of the Lake Helena Water Quality Restoration Plan to achieve improved water quality throughout the watershed will depend on commitment and participation by many local stakeholders, ongoing monitoring and research, and the previously described adaptive management approach.

60. **Comment:** Imposition of nutrient reductions on point source dischargers without corresponding reductions by non-point source generators will encourage the continuing proliferation of small rural lot developments served by on-site septic systems. Septic systems outside the city limits are a major cause of water quality degradation, and even appropriately constructed and maintained septic systems cannot treat wastewater to the level achieved by the city's treatment plant. The Lake Helena plan does not satisfactorily address this issue.

Response: We absolutely agree that water quality standards can only be attained and maintained by addressing both point and nonpoint sources.

Septic system reductions have been revised throughout the document (see response to comment # 31). However, as stated previously, conventional septic systems, by nature, have poor nitrogen treatment. Additional nitrogen treatment can be achieved with Level 2 systems, but at this point in time, neither the county nor state requires Level 2 treatment for most situations.

The long-term solution will likely only be resolved through watershed scale land use planning with a focus on water quality. This will require the combined efforts of the State, County, and all of the municipalities in the watershed. This plan is not intended to provide the long-term solutions. Rather, as described in the response to comment # 59, the current plan merely establishes the foundation and an overall framework for attaining and maintaining water quality standards.

61. **Comment**: Not only does the plan fail to describe a mechanism for reducing loading from existing septic systems, it also falsely assumes that there will no new septic systems. For this assumption to be true, the plan would need to propose a moratorium on all new septic system permits.

Response: The plan makes no assumption that there will be no new septic systems. To the contrary, an analysis is presented in Section 4.5.4 in which it is estimated that TN and TP loads may increase by as much as 43 and 78 percent, respectively, if population growth continues at current rates. Additionally, see response to comment # 31.

62. **Comment:** The City of Helena has been proactive in attaining compliance with water quality regulations. A recent $12 million upgrade to the wastewater treatment plant was undertaken to address ammonia-nitrogen effluent limits and the city consistently meets or exceeds discharge permit requirements. The Lake Helena TMDL plan would require the city to reduce nitrogen by another 92%. At the same time, no reductions are required for on-site septic systems and drainfields that are the largest contributor of nitrate pollution in the watershed. This constitutes an unfunded mandate that is unfair to the city residents and does not address the real problem. The components of the Lake Helena plan

addressing sediment, metals, and temperature also unfairly target point source discharges over non-point source controls.

Response: See response to comment # 11 and 31.

63. **Comment**: The Lake Helena plan's proposed pollutant load reductions have no viable legal basis in the applicable state statutes.

    Response: The basis for the proposed pollutant load reductions and TMDLs is articulated in the Montana Water Quality Act (Montana Code Annotated 75-5-703).

64. **Comment:** Comments on volumes I and II of the Lake Helena TMDL document provided by city staff have largely been ignored. I hope you take this opportunity to incorporate appropriate revisions to address the city's concerns and comments.

    Response: Responses to comments received on Volumes I and II are provided throughout this appendix.

65. **Comment**: The Lake Helena plan indicates that Silver Creek is impaired due to both arsenic and mercury, and yet only a TMDL for arsenic is presented. DEQ's research indicates that between 50 and 75 tons of mercury may have been discharged to Silver Creek along with the mill tailings from the Marysville 50-stamp mill. DEQ sampling showed elevated levels of mercury in stream bottom sediments throughout Silver Creek from Marysville to the Helena Valley. However, we did not find mercury in the water column. Arsenic is not a primary concern with DEQ abandoned mine cleanup plans for Silver Creek because levels are well below thresholds. Is it possible that the TMDL confused mercury with arsenic?

    Response: At this time, no TMDLs were completed for any mercury-impaired streams in the Lake Helena watershed. As stated in the Phase I impairment status report, "[In Silver Creek] The project team evaluated a total of four in-stream water chemistry samples taken between August 2001 and August 2003. Arsenic concentrations in three out of four samples exceeded the human health criterion. The average concentration of all samples was 42 percent higher than the human health criterion. The highest concentration was 2.3 times higher than the human health criterion. The evidence suggests that this segment does not meet the human health standard for arsenic." The arsenic TMDL presented in Appendix A is correct.